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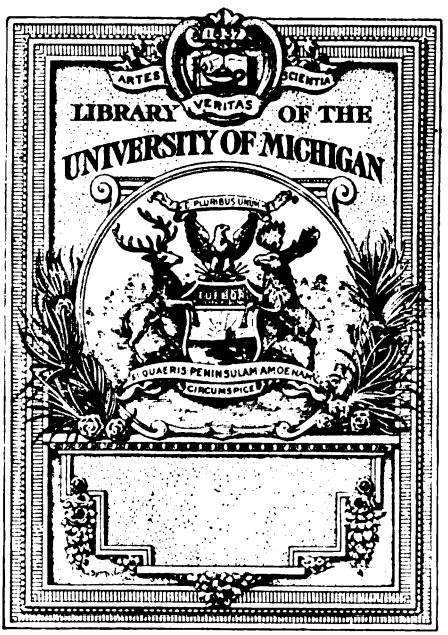

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COAL CUTTING MACHINERY.

BY ROBERT PEELE.

Coal-cutting machines are extensively used to replace hand labor in the work of "under-cutting" the coal, preparatory to breaking it by blasting or wedging. The objects in view are: (1) To economize in the cost of mining; (2) to decrease the proportion of "fines" produced; (3) to increase the rate of production of coal from a given extent of mine workings.

Coal cutters find their chief application in bituminous collieries, and under proper conditions it is unquestionable that by their use coal can be produced more cheaply than by manual labor alone. They are designed to groove or undercut the face or breast of coal, close to the floor and to a depth of several feet. The mass so undercut is subsequently broken down by a few comparatively light blasts. Fig. 1 shows a typical case of a reciprocating or pick machine, working in a thin vein.

Coal cutters may be divided into four classes:

1. Endless chain machines.
2. Rotary bar machines.
3. Disc or circular saw machines.
4. Reciprocating or pick machines.

The last named imitates in some respects the operation of a miner's pick. All of them may be driven by either electricity or compressed air, though electricity is now generally employed for cutters of the first three types. These will be only briefly de-

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scribed. Pick machines are almost invariably operated by compressed air, no entirely satisfactory electric driven pick having yet been placed on the market.

Endless Chain Cutters are built by several concerns, one example, the Jeffrey (type 16–D), being shown in Fig. 2. It consists of a stationary bed-frame, of two parallel steel channels, with the necessary cross-ties or braces. Within this frame

FIG. 1. Sullivan Coal Pick, Working in a Thin Vein.

is a T-shaped sliding frame, on the rear end of which is mounted the driving engine—a pair of small compressed air cylinders, say 5 in. diameter by 5½ in. stroke. The sliding frame carries an endless sprocket-chain, driven by a sprocket wheel and gearing from the engine. Each alternate link of the chain is provided with a socket, in which is set a cutting tooth or bit. The head of the sliding frame is composed of two parallel steel plates, as shown, between which, at the forward corners, are placed the idler sprockets carrying the chain. Mounted on each end of the frame are screw-jacks, for bracing the machine firmly in position while at work. The front jack is set against the face of coal, the other against a post or prop.

The cutting bits, held in their sockets by set screws, are straight-

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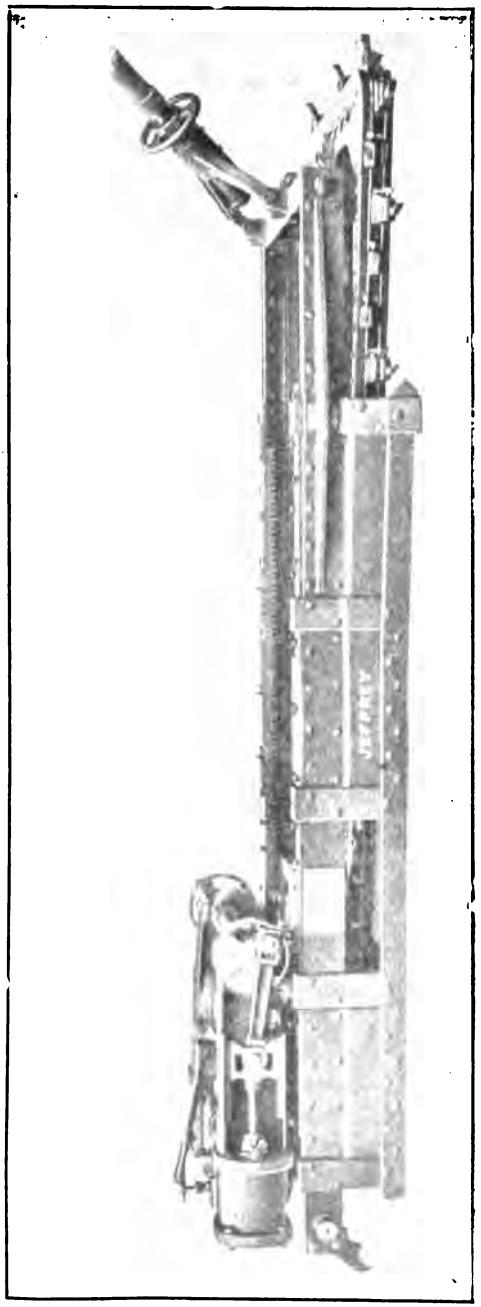

FIG. 2. Jeffrey Chain Machine.

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edged and point forward in the direction of motion of the chain. They are so shaped and staggered with respect to one another, as to "cover" the chain and cutter head, and make a groove in the coal about 4 inches in height, or sufficient to permit the cutter head to enter freely as the work advances. The sliding frame is fed forward automatically as explained below.

Fig. 3 shows the general plan and elevation of this machine, with some of the principal dimensions, and Fig. 4 is an enlarged plan and elevation of the compressed air engines and their accessory mechanism. Referring to Fig. 4 the engine crank-shaft *a* drives the countershaft *b*, through the gear wheels *c* and *d*. Keyed on *b* are: (1) The bevel gear *e*, engaging with bevel gear *f*, on the short vertical shaft *g*, which carries on its lower end the sprocket *h*, for driving the cutter chain; (2) the worm *i*, which, through the shaft *j* (and by another worm, as shown in the elevation), drives the gear wheel *k*, mounted loosely on the transverse shaft *l*. At each end of *l* are the small pinions *m*, *m*, engaging with long feed racks, bolted to the side channels of the stationary or main frame; (3) the small bevel gears *n* and *o*, which, through the shaft *p*, drive the worm *q*, engaging with the gear *r*, also mounted loosely on the transverse shaft *l*.

The effect of these two trains of gearing is to cause *k* and *r* to rotate in opposite directions, *r* having the more rapid movement. By means of the sliding clutch *s* on the shaft *l*, either *k* or *r* can be thrown in gear. When *k* is in gear the sliding frame carrying the driving mechanism, with the cutter head and chain, is fed slowly forward as the undercut advances. When *r* is thrown in gear, after the cut is finished, the feed is reversed and the sliding frame and cutter head are rapidly run back, preparatory to shifting the machine for the next cut.

The depth of undercut made by chain machines ranges from 4 to 7 feet; width of groove, from 39 to 44 inches. By shifting the machine, successive cuts are made side by side, over the required length of face. In regular operation, from 100 to 150 square yards can be undercut in 10 hours, depending on the character and hardness of the coal and upon whether the work is in "rooms" or "long-wall" mining. Two men are required: a machine runner, and a helper to remove the débris from the under-

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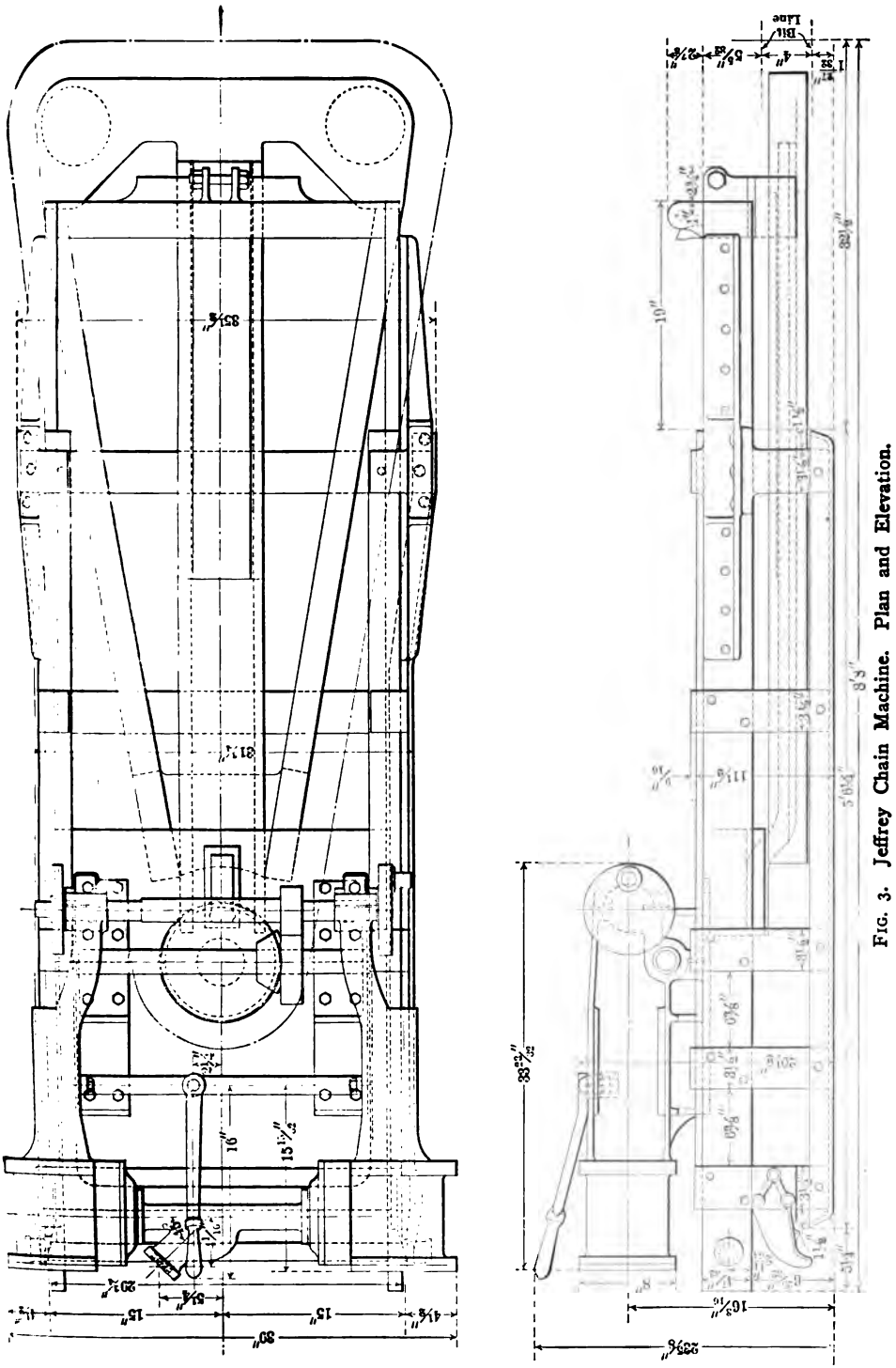

FIG. 3. Jeffrey Chain Machine. Plan and Elevation.

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cut and assist in handling the machine. Tests show that the power required varies from 8 to 14 horse-power, an average of 12 horse-power being obtained from numerous tests in coals of varying hardness and quality.

Chain cutters of a number of different makes are in use, operated by either electricity or compressed air. Among them are those of the Jeffrey Manufacturing Co., Sullivan Machinery Co., Link Belt Machinery Co., and the General Electric Co. (Sperry machine). For long-wall mining, some of them are self-propelling and operate continuously along a face of coal of any desired extent. A post is set at one end of the face and to it is attached a chain leading to the cutter, the chain being wound in by a small drum, geared to the driving engine.

Rotary Bar Cutters are not so widely used as the chain machines. They have a bed-frame similar to that of the chain cutter and the inner sliding frame is fed forward in the same way. The cutter head carries a horizontal shaft or bar, in which is set a series of bits. This cutter bar is rotated by a sprocket-chain driven from the air engine (or electric motor) in the rear. The bar is from 3 to 3½ feet long, the width of undercut being slightly greater, owing to the projection of the end bits; speed of rotation of the bar, about 200 revolutions per minute. Under favorable conditions the time required to make a cut 5 to 5½ feet deep ranges from 6 to 7 minutes. In room work, from 70 to 100 square yards can be undercut in 10 hours; more in long-wall work. The power required usually ranges from 14 to 16 horse-power.

Disc or Circular Saw Cutters are made and used almost exclusively for "long-wall" mining. In the past they have been employed more commonly in Europe than in this country. Their general construction will be understood by reference to the accompanying illustrations of the Jeffrey (American) machine, style 22–C. Figs. 5 and 6 are perspective views of opposite sides and Fig. 7 a plan and side elevation, on which only a part of the periphery of the cutter wheel is indicated.

The driving machinery is compactly arranged on a bed-frame, mounted on wheels, to run on a temporary track laid along the face of coal. (The machine shown in the cuts requires but a

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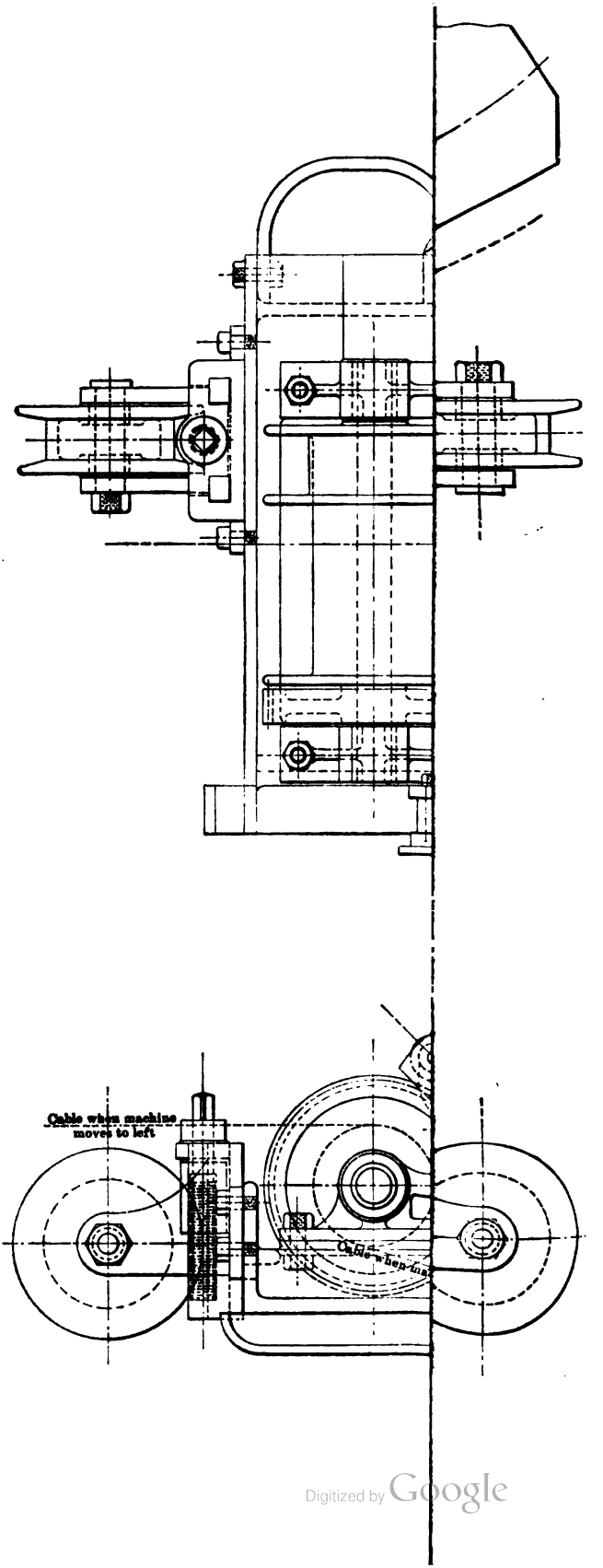

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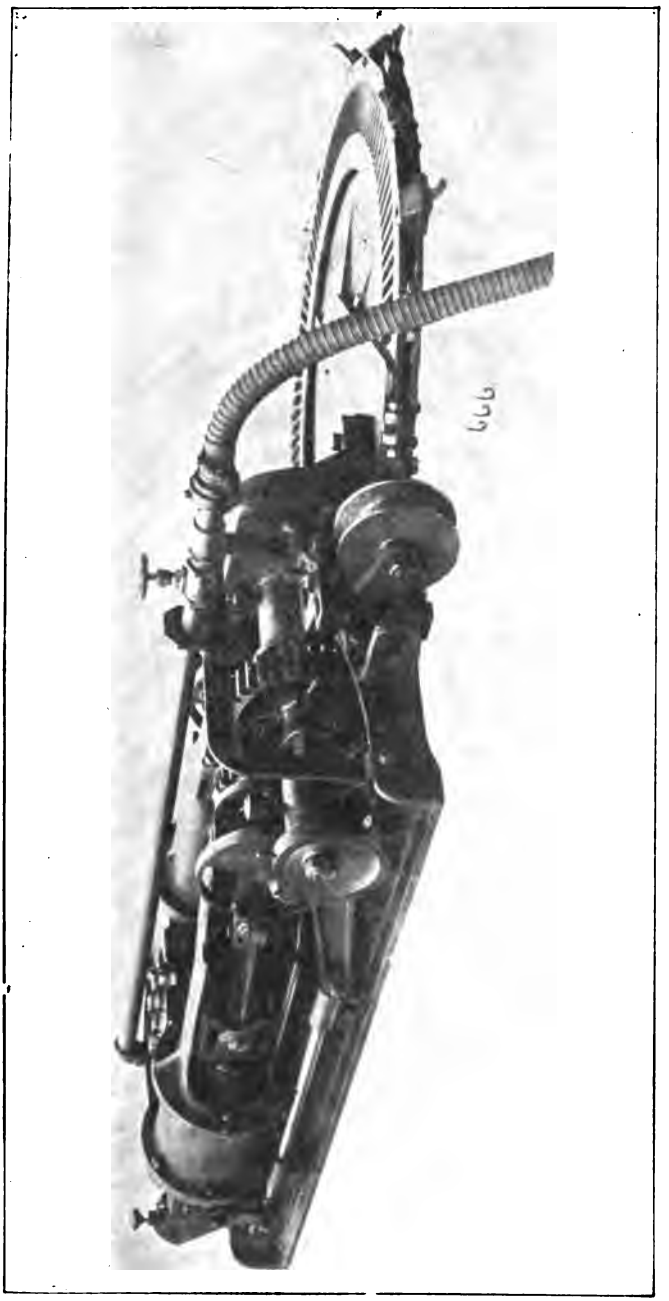

FIG. 5. Jeffrey Disc Coal Cutter, Style 22—C.

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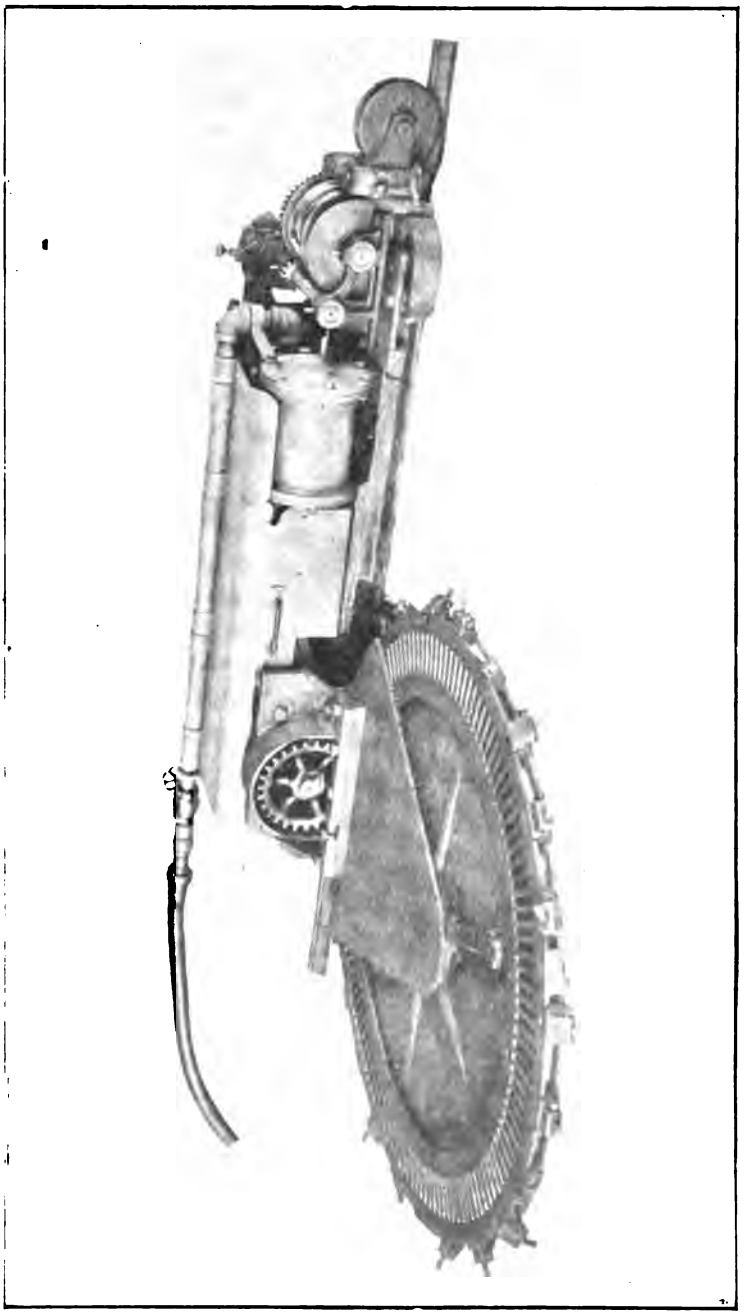

FIG. 6. Jeffrey Disc Coal Cutter, Style 22—C.

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single line of rails.) A cutter wheel, from 3 to 4½ ft. in diameter, is supported by a heavy bracket on one side of the frame, and projects a distance nearly equal to its own diameter. On the periphery of the wheel is set a series of staggered bits, cutting a groove of sufficient height or width, to admit the disc freely. The cutter wheel is driven by double reduction gearing, from a pair of compressed air cylinders, with quartering cranks. The speed of rotation ranges usually from 15 to 30 revolutions per minute, depending on the character of the coal. When in operation the whole machine is automatically pulled along the face of coal by a small wire rope, made fast to a post at the end of the face, and wound in by a drum geared to the driving engine.

The disc cutter is a useful machine for long-wall work, specially in thin or steeply pitching veins, where it would be difficult or impossible to operate cutters of the other types. It works back and forth along the face, almost as well up the dip as down. The linear speed of feed is from, say, 8 to 25 inches per minute. These machines will undercut from 90 to 100 square yards per 10 hours, under average conditions.

Among the English machines of this class may be mentioned the Gillott and Copley, Yorkshire, Rigg and Meiklejohn and the Winstanley. Though they vary in details, their general construction and operation are essentially as described above.

Reciprocating or Pick Machines.—At the present time these constitute the most important of the four classes of coal cutters. In their general construction they possess many points in common with the reciprocating rock drills; which, in fact, have furnished the basis of the design of several well-known makes of pick machine. All work without rotation of the piston and bit, since in undercutting there is no question of preventing rifling of the hole, as in rock-drilling. Variations in the valve-motion are noticeable, some of the designs being entirely different from the spool and tappet valve motions.

The first pick machine was invented in 1858, by E. Simpkins, of Allegheny City, Pa., but it was of crude design, imitating the movements of the miner's pick. Next in order of seniority is probably the Harrison machine, invented in 1877. This was followed in 1881 by the Yoch coal pick. From time to time both of

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these machines have been altered and improved in many of their features. Of later date are the Sergeant and the Sullivan picks. All of the above are operated by compressed air.*

The general lines of this class of coal cutter, together with the mode of operation, are shown in Fig. 1. The machine is mounted on a pair of wheels and when at work is placed on a wooden platform, about 3 ft. wide by 8 ft. long, which slopes towards the face of coal, at an angle of, say, 5 degrees. By this means, the recoil of the blows is nearly neutralized by gravity and the machine is kept up to its work. The operator chocks the wheels with wooden blocks, sometimes strapped to his boots, and directs the blows by swinging the machine from side to side, with the supporting wheels as a fulcrum. As shown by the several cuts, the front cylinder head and piston rod are very long, to give the machine a sufficient reach. A horizontal width of 4 or 5 ft. of undercut is thus readily commanded. The depth of cut is rarely greater than 5 feet. A helper clears away the débris with a light, long-handle shovel, and assists in moving and setting up the machine.

Most pick machines run at speeds of 200 to 250 strokes per minute. The lower speed machines probably have some advantage, because, as each individual blow is directed by the operator, he can increase the efficiency of the work if he has time between strokes to point the pick in such a manner that it will do most execution. In coal of average quality, an undercut of say 4 ft. by 4 ft. in horizontal area can be made in 16 to 18 minutes. The platform can be shifted sidewise to the next position and the bit changed, if necessary, in 8 to 10 minutes. The height of undercut is 12 to 14 inches at the face, tapering to 3 in. or 3½ in. at the bottom. On completing the cut, the coal is shot down by light blasts; or, in gassy mines, is sometimes broken by wedging. Under favorable conditions, good operators can undercut, per shift, from 75 to 85 linear feet of face, to a depth of 4 to 4½ feet; in competition trials much faster work is often done. Fair, average work would be from 60 to 65 ft. of undercut, 4 ft. deep, per shift.

* It may be added that an electric-driven coal pick, the Thomson-Houston solenoid, has been put on the market.

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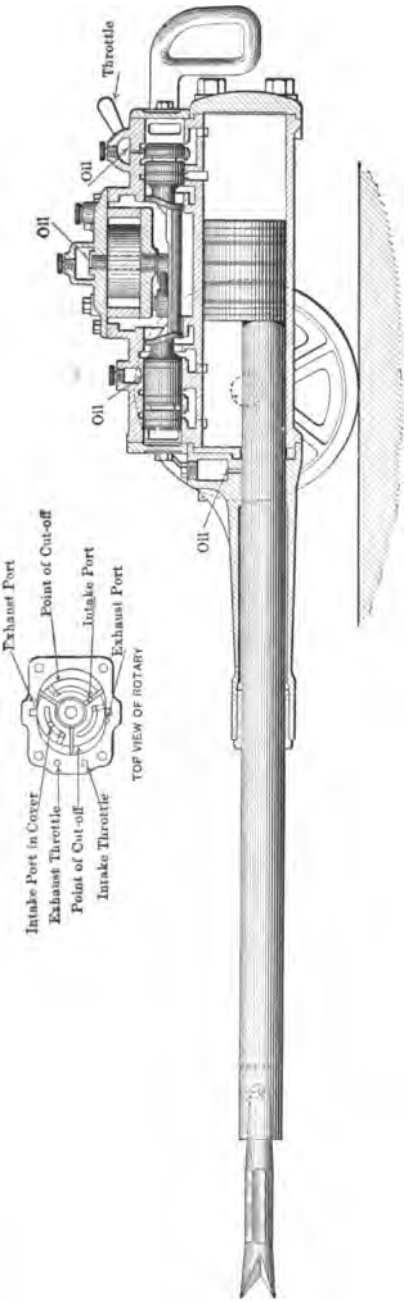

FIG. 8. Harrison Pick Machine.

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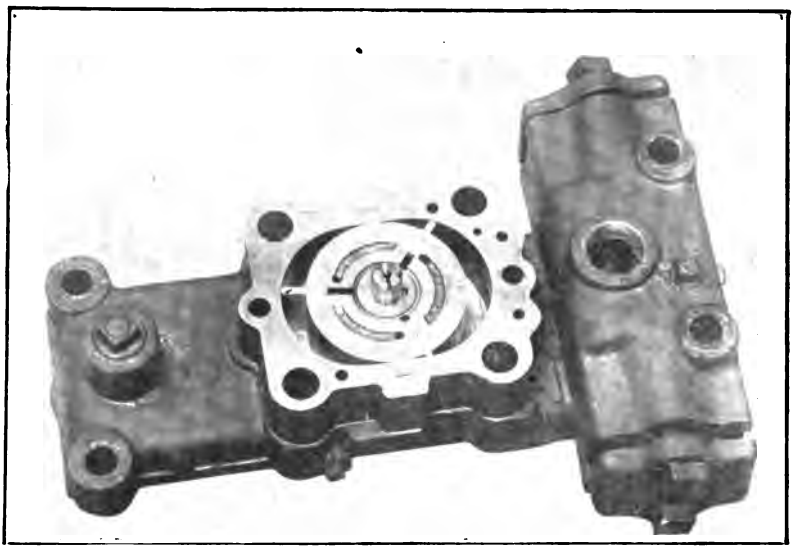

FIG. 9. Rotary Engine for Operating Valve of Harrison Coal Pick. Top View.

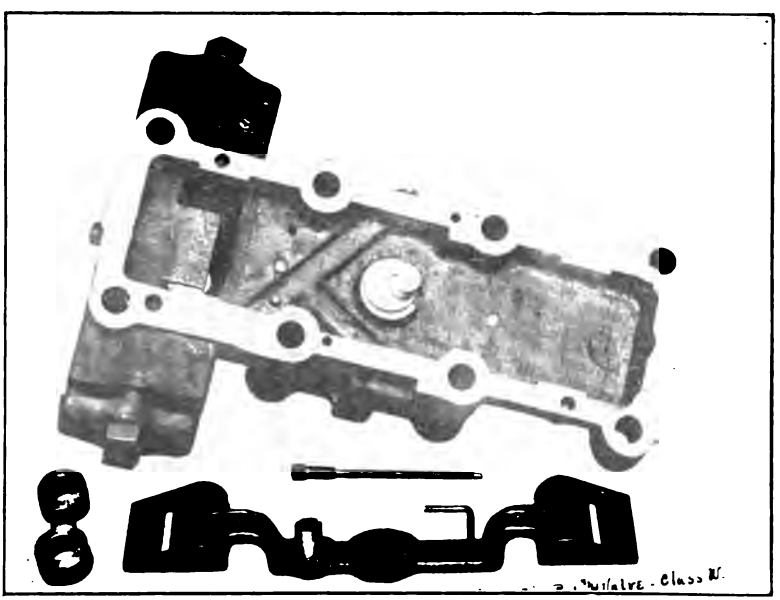

FIG. 10. Rotary Engine for Operating Valve of Harrison Coal Pick. Bottom View.

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Harrison Pick Machine.—Fig. 8 shows a longitudinal section of models "PG" and "PW" of this machine. The valve is a long, double spool, actuated through a crank and connecting rod by a small horizontal rotary engine set above the middle of the valve chest. A separate plan of the rotary, with its ports, is also shown in the cut; the main cylinder has double ports at each end, to obtain cushioning of the stroke, and to enable the machine to run with a short stroke when desired. Figs. 9 and 10 are perspectives respectively of top and bottom of the valve motor for models W of the Harrison coal pick, the latter showing also the long slide valve and its connecting rod.

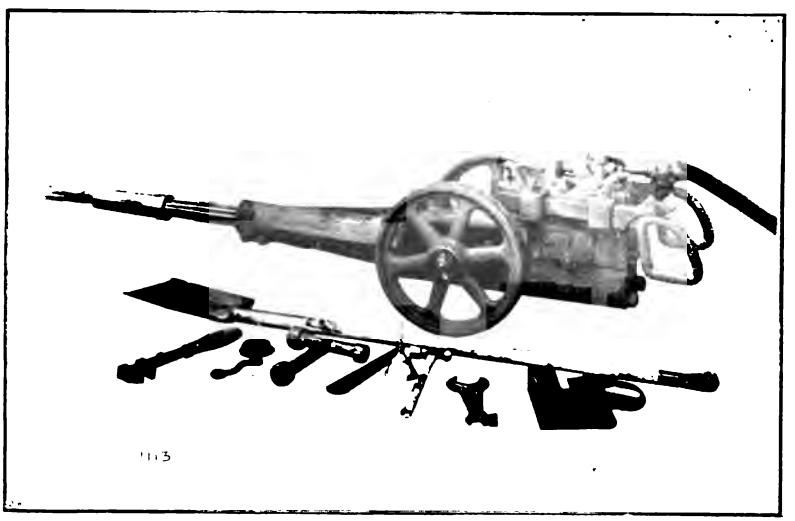

FIG. 11. Ingersoll-Rand Coal Pick.

These machines are made in heavy and light patterns, the former weighing about 700 lbs., the latter 500 lbs. The heavier pick will cut to a depth of 5 ft. and is specially adapted for "shearing"; that is, making vertical cut or grooves, on one or both sides, in driving entries for developing a coal seam, or for haulage- and air-ways. For this purpose, supporting wheels of 34 ins. or 40 ins. diameter are provided, in order to raise the machine high enough to give the requisite reach. Smaller wheels are used for ordinary undercutting.

"New Ingersoll" Pick Machine (Fig. 11).—The valve-motion

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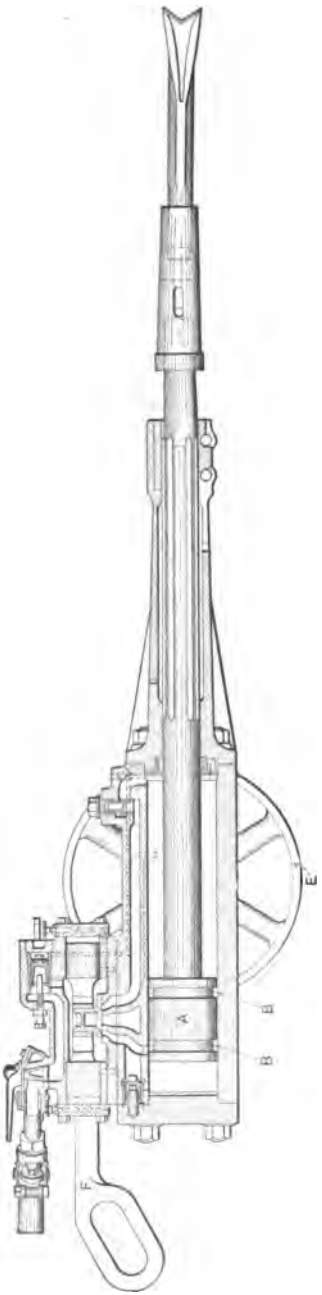

FIG. 12. Ingersoll-Rand Coal Pick. Longitudinal Section.

of this machine is developed from the spool-valve rock drills of the Ingersoll-Rand Co., with the important difference, however, that the air ports are controlled by a combination of slide and spool or plunger valves. Fig. 12 is a longitudinal section and Fig. 13 a diagrammatic sketch of the valves, ports and chest, developed in one plane to show the relations between the several ports and the operation of the valve motion.

The main ports S, S^1 of the cylinder O are controlled by the slide valve G, on the back of which is a lug H, engaging with the double spool-valve F. Air is admitted alternately to the opposite ends of F through the auxiliary ports J, J^1 which in turn are controlled by the auxiliary slide valve K and its actuating spool-valve F^1. This valve is thrown by air passing through the small ports N, N^1, N^2 and N^3, which, by a cross-over arrangement as shown, connect on either side with the main ports S, S^1. Thus the rear end of the chest of spool-valve F^1 is connected with main forward port S and the forward end of F^1 with the rear main port S^1; so that, when air is admitted to the main cylinder O through the rear port S^1, a small portion of it passes through N, N^3 and drives back

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the valves F^1 and K. This movement admits air from F^1 through port J^1 to spool-valve F and throws back the main slide valve G; thus opening main port S to live air and S^1 to the exhaust. Some of the air passes from S through the rear auxiliary port N^1, N^2 to the valves F^1 and K, by which first K and then G are thrown forward, reversing the main ports and completing the cycle of movements. As the main port S^1 is of larger area than the port S, the forward stroke of the machine is more powerful than the back stroke.

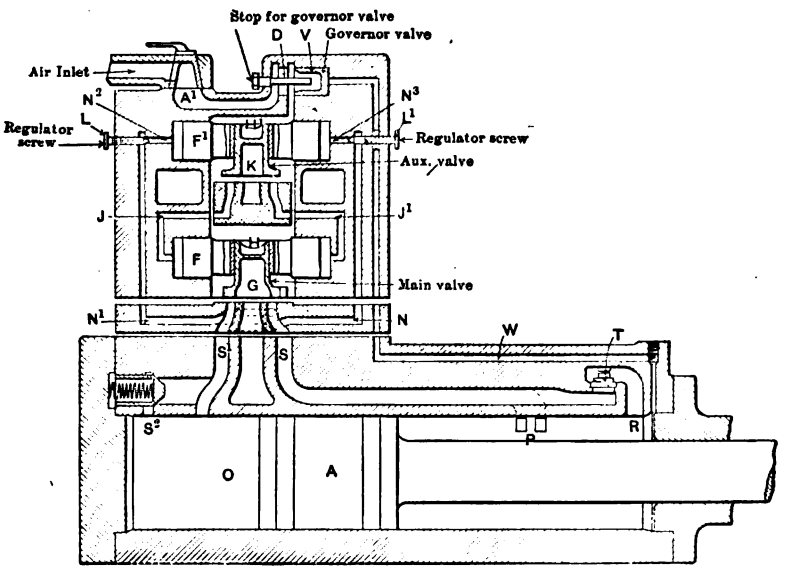

FIG. 13. Ingersoll-Rand Coal Pick. Diagram of Valves and Ports.

In addition to the above parts there are two small regulating screws L and L^1, by which the operator can regulate the speed of the auxiliary valves F^1 and K and hence of F and G. But, while the effect of the regulating screws is to govern the speed of stroke, they do not greatly influence the force of the blow. The forward stroke is cushioned, as follows: When the piston passes the double port P the exhaust ceases, since at this point the bit should strike its blow. Hence, if the pick misses the coal or should momentarily be swung out of contact with it, the piston on advancing beyond P compresses the air in the forward end of the

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cylinder to a pressure higher than that in the valve chest A^1, which is connected with the cylinder by the small port *W*. This high pressure air forces back the governor valve *V*, wholly or partly cutting off the inlet air on its way to valve *K*, so that the machine will run at reduced speed and force until the bit again strikes the coal before the piston has covered the port *P*. The regular exhaust then takes place, relieving the pressure transmitted through *W* to the governor valve, which opens automatically and the machine at once resumes regular operation. By means of the stop *D* the throw of the governor valve may be adjusted as desired.

The air on which the piston cushions is confined by the spring check valve, *T* in the port *S*; and the back stroke is begun by the elasticity of the cushioned air. No live air can enter this end of the cylinder until the piston has advanced far enough on the back stroke to reduce the pressure in the cylinder below that of the live air in port *S*, plus the resistance of the check valve spring. A smaller degree of cushioning is similarly produced on the back stroke by the arrangement of the port S^1 and valve S^2.

The Ingersoll pick is made in three sizes of cylinder, viz., 4½ in., 5 in. and 6 in. diameter, but there are five models, varying in weight, power and length, according to the depth of undercut desired. The maximum depth of cut ranges from 4 to 6 feet and the gross weights of machine, from 550 to 950 lbs. Standard wheels for mounting the pick are 14 in. and 17 in. diameter. Larger wheels may be used for shearing.

Sullivan Pick.—Fig. 1 is a general view of the machine. It is made in three sizes, with cylinder bores of 4½ in., 4¾ in. and 5⅛ in., which undercut to maximum depths of from 4½ to 6 feet. The weights range from 650 to 850 lbs. Air consumption of the 4½ inch machine, about 115 cu. ft. of free air per minute; of the 5⅛ inch machine, 135 cu. ft.

A longitudinal section of one of the larger sizes is given in Fig. 14, and on p. 18 a descriptive list of the principal parts. It will be seen that in some of its features this machine differs greatly from those previously described. The spool- or piston-valve (123), by its reciprocations, throws the long flat valve (126), which in turn controls the main ports (148 and 149) and the secondary ports between them. These secondary ports serve

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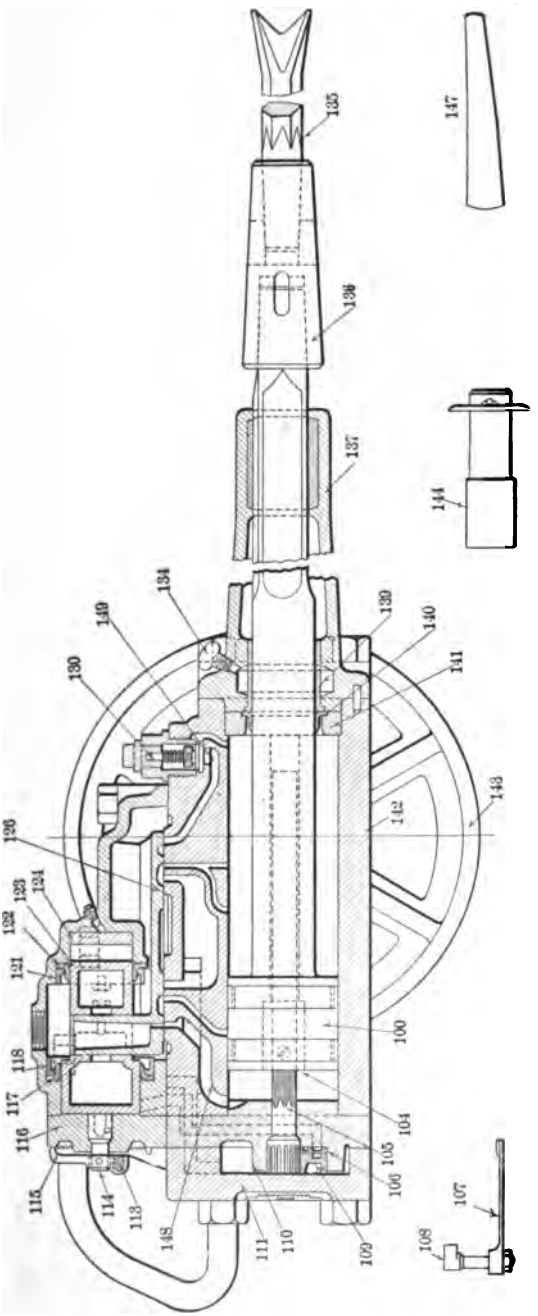

FIG. 14. Sullivan Coal Pick. Longitudinal Section.

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to produce cushioning at each end of the stroke, in a manner similar to that of the Ingersoll-Rand machine. A check valve (130) is inserted in the forward main port (149), and, when the pick does not strike the coal, the piston runs forward far enough to form an air cushion in the front end of the cylinder. This closes the check valve, and prevents admission of live air on the return stroke, the first part of which is made by the cushioned air. Injury to the cylinder head is thus prevented, as well as annoying shocks to the machine runner.

List of Principal Parts (Fig. 14).

100. Piston (bare).
104. Rifle Hut.
105. Rifle bar, with gear.
106. Seat for 109.
107. Spring pointer for 108.
108. Steam for adjusting 106.
109. Reverse valve.
110. Valve plate.
111. Cover for 110.
113. Spring for 115.
114. Regulating valve.
115. Index lever for 114.
116. Head (bare) for 127.
117. Packing leather (large) for 123.
118. Ring for 117.
120. Binding screw for 118 and 122.
121. Ring for 122.
122. Packing leather (small) for 123.
123. Valve (piston).
124. Buffer for 123.
126. Valve (flat).
130. Check valve
134. Plug for oil hole.
135. Pick.
136. Chuck.
137. Head (front) for 142.
139. Bushing in 137.
140. Packing, leather for 100.
141. Collar for 140.
142. Cylinder (bare).
144. Trunnion for wheel.
147. Drift-Key for backing out pick.

In the hollow piston is set a rifled-nut (104), with which engages the rifle-bar (105). As the forward end of the piston rod has flattened sides, making it nearly square in section, it cannot rotate like that of a machine-drill. Hence, at each stroke the rifle-bar is caused to rotate. The small gear cut on the back end of the rifle-bar causes the rotation of the reverse valve (106 and 109). This valve in turn controls the movements of the spool-valve (123), through the ports shown by dotted lines in the rear end of the cylinder. By means of a regulating valve (114), on the back of the main valve chest, the operator adjusts the speed of stroke, as the conditions under which the machine is working may require. The Sullivan pick runs at a moderate speed, which has the advantage of enabling the operator with more certainty to direct each blow where it will do the most efficient work.

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Ingersoll-Rand "Radialaxe" Coal Cutter.—This machine is intended for shearing in entry work, as well as for undercutting. As originally designed it consists essentially of a long-stroke rock drill, mounted on a column, and provided with a worm and worm-wheel sector. A hand wheel on the worm spindle enables the operator to swing the entire machine while at work, in either a horizontal or vertical arc. Long-shank bits are used, to give the machine the necessary reach.

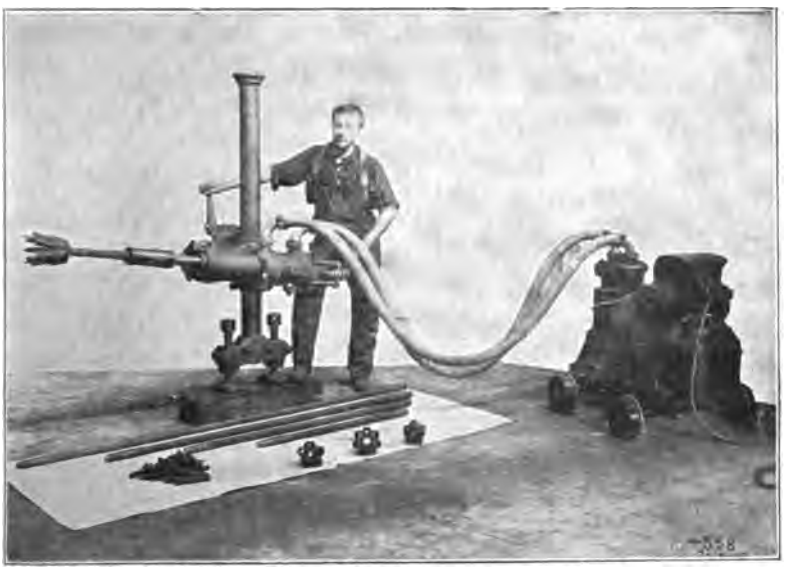

FIG. 15. Ingersoll-Rand "Radialaxe" Coal Cutter.

The latest form of the "Radialaxe" is shown in Fig. 15 and is an adaptation of the Temple-Ingersoll Air-Electric drill. In this design the gearing for swinging the machine is changed in some unimportant details. The bit, or group of bits, as shown, are set in a rosette socket, held by friction only on the tapering end of the drill shank, which is similarly inserted in the deep socket of a long chuck. The individual bits are thus readily removed by sharpening and replacement when broken.

Pneumelectric Coal Puncher.—Amongst the coal picks this machine occupies a class by itself. As its name implies, it combines the use of compressed air and electricity in a single piece of

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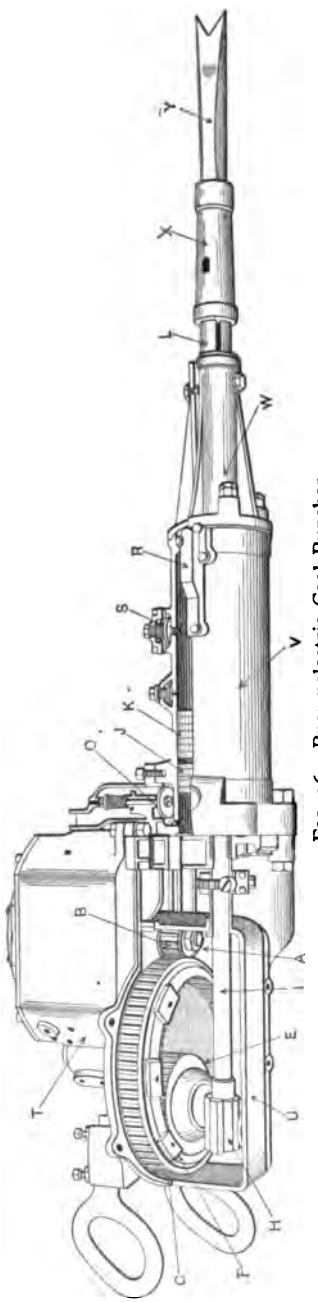

FIG. 16. Pneumelectric Coal Puncher.

mechanism, consisting of a small electric motor, which drives a pair of independent pistons in a cylinder. This design may have been suggested by the Temple rock drill. Fig. 16 shows the general construction. The casing *T* contains the motor, with its armature shaft *A* in a vertical position. To change its rotary motion to the rectilinear motion required for the pistons, the following device is employed. The driving pinion *B* engages with the large horizontal gear-wheel *C*, which has a solid web, carrying a stud *D* (Fig. 17). Mounted on *D* is a small gear *E*, and a crank with crank-pin *G*. Within the main gear *C*, and attached rigidly to it, is another gear *F*, with internal teeth, which engages with and drives the gear or crank-pinion *E*; *F* having 66 and *E* 33 teeth. Referring to the two diagrams in Fig. 17, it will be seen that the gears are so proportioned that the stud *D* revolves in a circle concentric with *F* and of one half its pitch diameter. The gear *E*, which revolves freely on *D*, is carried with *D*, and causes the crank-pin *G* and the cross-head *H* to reciprocate between the guides. To the cross-head is attached the piston rod *I*, with its piston *J* (Fig. 16).

The cylinder *V* contains two pistons, entirely unconnected with

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each other: the rear or driving piston *J*, already noted, and the forward piston *K*, with its rod *L* and chuck *X*, for holding the bit *Y*. In starting the machine on its first forward stroke, piston *J* simply pushes *K* forward, air meantime entering the cylinder behind the piston, through the valve *O*. On the back stroke of *J*, the air in the rear of the cylinder is compressed, occupying the clearance space and the passage between the cylinder and the valve *O*. At the same time the air between the pistons is rarefied, thus causing *K* also to make its return stroke by suction, while air enters freely through a port at *R*. At the end of the back stroke,

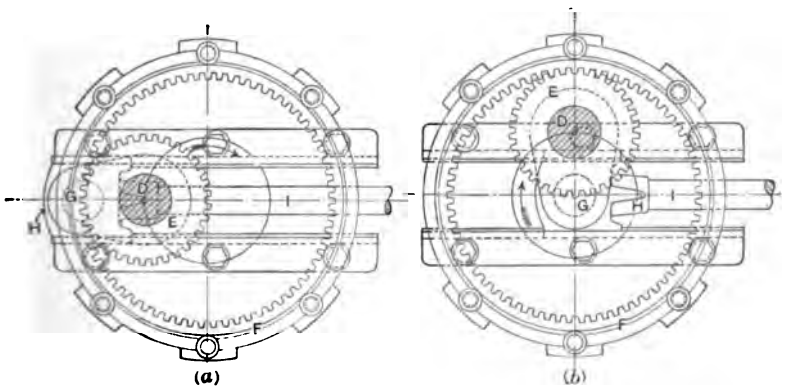

FIG. 17. Pneumelectric Coal Puncher. Diagram of Gearing.

the air passages below the valve *O*, referred to above, lie between the pistons, whereby the charge of compressed air enters the cylinder and drives the piston *K* forward on its first regular stroke. The stroke is cushioned on air confined in the end of the cylinder, after *K* passes the port at *R*. Piston *K*, having completed its forward stroke, is followed by piston *J*, the air between them being discharged into the atmosphere through the valve *S*. The return stroke is then made by both pistons, as at first.

The diameter of the cylinder is 6¼ inches, and the clearance spaces at the rear end are proportioned to produce a final or working pressure of 95 to 100 lbs. The motor is designed to run at three speeds, under the control of the operator, giving to the pick 140, 160 or 180 strokes per minute.* It is stated that 7 H.P. are

* This description is abstracted in the main from an article by Timothy W. Sprague, in *Mines and Minerals*, April, 1908, p. 427.

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required to run the machine, which is in successful operation at a number of collieries. The behavior of the motor, while at work, is shown by the following records, taken after two hours' operation.

Test.	Input.		Temperatures, Degrees Centigrade.				
	Amps.	Volts.	Room.	Armature Winding.	Commutator.	Brush.	Field Coils.
1	26	220	17	79	75	77	70
2	24	220	24	73	64	not recorded.	

All temperatures include room temperatures prevailing during the tests. It may be noted, respecting this machine, that, as the compressed air is released at the same point of every stroke, the power required of the motor is constant; in other words, the motor is not subject to overloads.

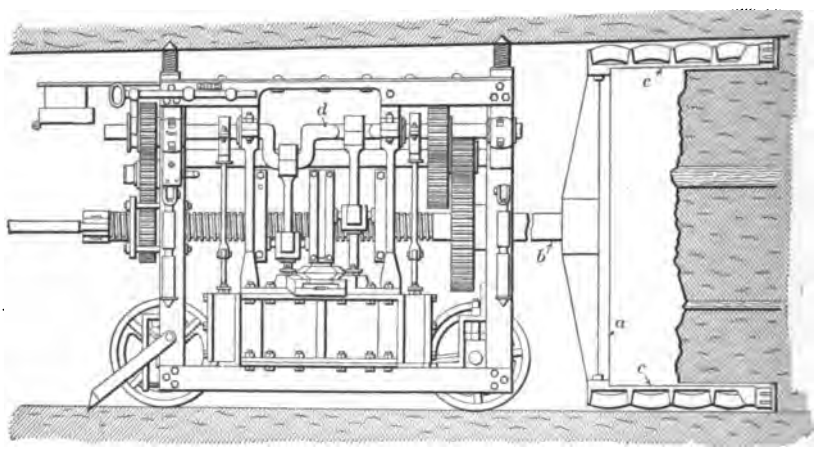

FIG. 18. Stanley Coal-heading Machine.

The Stanley Header, originally brought out in England, is intended for development work in collieries, driving circular headings, for entries, airways, etc. In its earlier form (Fig. 18) a heavy cross-head, *a,* mounted on a central screw shaft, *b,* and carrying at each end a horizontal arm, *c,* cuts an annular groove from 3 to 4 inches wide. A central core of coal is thus left, which either breaks up and is shovelled back as the work advances, or is blasted or wedged down from time to time, if necessary. The operating mechanism consists of a pair of compressed air cylinders,

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about 9 ins. by 9 ins. from the crank-shaft, *d*, of which the screw-shaft is driven by gearing. Differential gearing is used to produce the feed, as shown. The whole is carried in a frame on wheels, held firmly when in operation by jack-screws set against the roof. The machine is narrow enough to permit a man to pass alongside to the front, to throw back the broken coal and keep the cutter head free.

Several modifications of the Stanley Header have been introduced in this country and abroad. By one of them, the entire section of the heading is taken out in a single operation. To accomplish this, the cross-head and arms, on the central spindle, are replaced by a very flat, cone-shaped head, which carries a number of individual cutter bits, arranged in diametral lines on the surface of the cone. The circular paths transversed by these bits of cover one another, so that the whole mass of coal is broken up.

This modification of the original machine has done good service in some of the bituminous mines of western Pennsylvania, such as those of the Frick Coal and Coke Co. The average speed of advance, under favorable conditions, is 2½ to 3 feet per hour, including the time occupied in moving and setting up after a run. In one case 2,254 linear feet of entry were driven at an average speed of 17 ft. per 9 hours, and an average working cost of 40 cents per foot. In a mine of the Frick Co., 1,475 feet have been driven without a parallel entry for air connections, the exhaust air being discharged backward through an 8-inch pipe. This exhaust assists in ventilating long headings.

For rapid development work, as in opening a bituminous colliery for the "long-wall" method of mining, the Stanley Header is specially advantageous. It has been used, also, by the Colorado Fuel Co., with the following results, as compared with hand work:

HAND LABOR.

2 men, 1 10-hr. shift	$ 4.00
Paid to men for coal produced in driving, 4½ tons @ .50c.	2.25
Cost	$ 6.25

Distance driven in 10 hours, 3 feet.

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MACHINE WORK.

1 operator, $3.00; 1 helper, $2.50	$ 5.50
3 shovellers to load coal behind machine @ $2.00	6.00
Compressed air, repairs, depreciation and interest	3.50
Squaring up corners, for timbering and track	5.00
Cost	$20.00

Distance driven in 10 hours, 20 feet.

Crediting to the machine work the coal produced, viz., 15½ tons @ .50c. loaded, the net cost for the 20 feet of entry was $12.25, or $1.84 per yard. This shows a substantial gain over hand work, both in speed and cost.

Auger Drills.—Though not strictly in place here, reference may be made to the rotary auger drills, for boring holes for blasting in coal, rock-salt and other soft material. They are operated by small compressed air engines—some also by electricity.

Two of these are built by the Ingersoll-Rand Company. The first is of the breast-drill type, similar in general form to a machinists' breast drill. It has a 3-cylinder motor, which can readily be reversed for withdrawing the bit from the hole; total weight, exclusive of the bit, 18 lbs. The second, a heavier machine, is designed to be mounted on a column or bar.

A compressed air auger drill, mounted on single or double column, is made by the Jeffrey Manufacturing Co. Total weight, for a 6 foot vein, 183 lbs. The speed of the engine is about 3,000 revolutions, and that of the threaded feed shaft, 850 revs. per minute.

Comparison of Coal Cutters.—The chain and disc machines work best in clear coal, of uniform quality and not too hard. For hard, "bony" coal, or coal containing streaks of pyrites, or "sulphur balls," the pick machines are preferable; because the operator can regulate the strength of the blow and so direct the machine as to cut around a hard place, when necessary. For this reason, however, the pick machine requires more skill on the part of the operator.

Somewhat less slack and fines are made by the disc and chain machines, as the volume of undercut is smaller; but, taking into account the greater flexibility and variety of work possible with the picks, the latter are in many respects advantageous for all around

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work. Moreover, in the numerous mines whose product goes chiefly to coke ovens, the larger quantity of fines made by the pick machines is immaterial. Also, in solid, hard coal, the higher undercut of the pick machines causes a more complete breaking up of the whole mass when blasted down, and the coal, therefore, is sometimes more readily loaded.

For chain and disc cutters a fairly good roof is desirable; otherwise, props may have to be set so close to the breast or long-wall face, as to interfere with the manipulation and shifting of the machines. Coal cutters of all the types can be worked in seams as thin as about 30 inches, or even less; though they are more conveniently operated in seams not less than 36 to 42 inches thick. The continuous feed chain and disc machines are specially useful for pitching seams in long-wall work, as they will operate with almost equal facility either up or down the pitch.

The "mining rate," or cost of mining by hand, together with the character of the coal seam, will usually determine whether coal cutters can be economically applied in a given mine or district. In general, it may be stated that in seams of average quality and thickness, when the cost of hand mining in the district is not less than 50 to 55 cents per ton (including loading the coal), a saving may be effected by introducing machines.

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EFFECT OF THE INCLINATION OF THE STADIA ROD UPON STADIA DISTANCES.

By BORIS LEVITT, C.E.

Among the many errors which enter into stadia work there are also those due to the inclination of the stadia rod.

The errors due to that are small for small vertical angles, but they become quite appreciable as the vertical angles become larger.

The effect of the inclination of the stadia rod upon distances is to introduce errors of both signs, depending upon the degree of inclination of the rod, making the reduced distances longer or shorter, as the case may be, than the true distance.

The effect of the inclination of the rod upon the vertical angles is to decrease the vertical angle by some small angle if the rod is tipped away from the instrument, and to increase the vertical angle by some small angle if the rod is tipped toward the instrument, the middle wire of the instrument being moved, of course, to set at a fixed point on the rod.

In what follows an attempt will be made to trace the effect of the inclination of the rod upon the reduced horizontal and vertical distances and upon the vertical angles.

Fig. A represents a transit directed upon a stadia rod OP held in a vertical position, the line of collimation of the telescope AB being horizontal and normal to the rod.

Let w = interval between stadia wires.

f = focal length of the object glass.

l = distance from the axis of rotation of the telescope to the center of the object glass when the telescope is focused for the average of distances.

S = length intercepted on the stadia rod by the stadia wires.

A = axis of rotation of the telescope.

F = principal focus of object glass.

L = distance from the principal focus F to the stadia rod.

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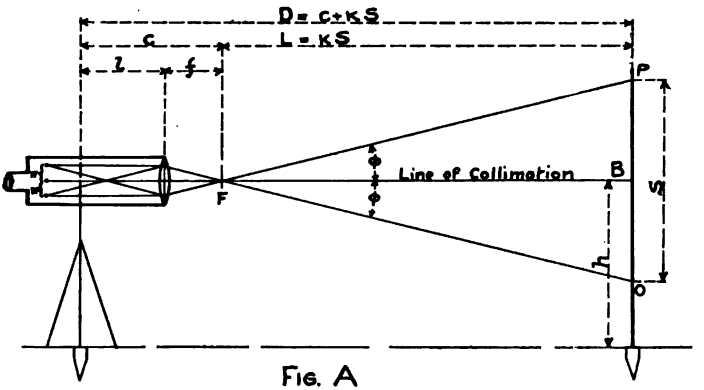

FIG. A

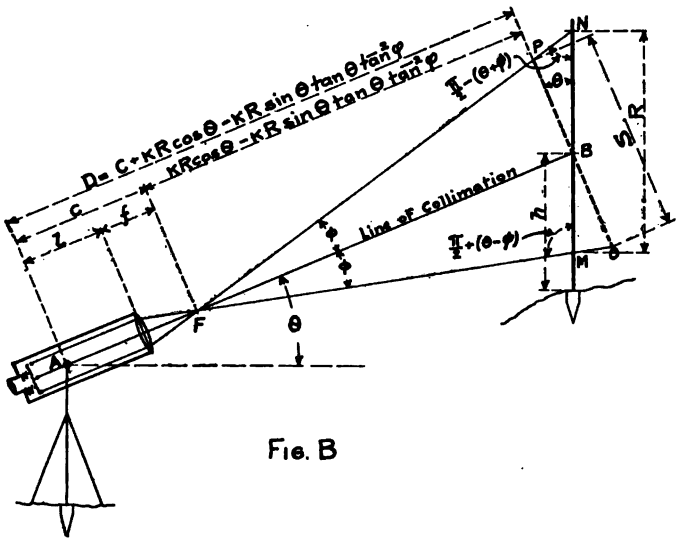

FIG. B

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Then, because the rays pass through the principal focus F, they are parallel between the object glass and the stadia wires, and by similar triangles

$$L : S = f : 2w, \text{ or } L = f/2w \cdot S$$

The distance required is

$$D = (l + f) + L = (l + f) + f/2w \cdot S$$

The terms $(l + f)$ and the ratio $(f/2w)$ are both constant quantities to be determined for each individual instrument, therefore letting $(l + f) = C$, and $(f/2w) = k$, the required distance

$$D = C + kS \qquad (1)$$

Fig. B represents the same instrument directed upon a vertical rod, MN, the line of collimation of the telescope being inclined to the horizon.

Let θ denote the vertical angle which the line of collimation makes with the horizon, and let

$$\phi = \tan^{-1} w/f$$

Through B draw a straight line perpendicular to AB, and intersect the rays FN and FM (produced) in P and O respectively.

From ΔFBM,

$$BM = FB \left\{ \frac{\sin \varphi}{\sin [\pi/2 + (\theta - \varphi)]} \right\}$$

From ΔFBN,

$$BN = FB \left\{ \frac{\sin \varphi}{\sin [\pi/2 - (\theta + \varphi)]} \right\}$$

$$\therefore BM + BN = MN = FB \sin \varphi \left\{ \frac{1}{\cos (\theta - \varphi)} + \frac{1}{\cos (\theta + \varphi)} \right\}$$

$$= FB \sin \varphi \left\{ \frac{\cos (\theta + \varphi) + \cos (\theta - \varphi)}{\cos (\theta - \varphi) \cos (\theta + \varphi)} \right\}$$

$$= FB \sin \varphi \left\{ \frac{2 \cos \theta \cos \varphi}{\cos^2 \theta \cos^2 \varphi - \sin^2 \theta \sin^2 \varphi} \right\}$$

$$= 2FB \left\{ \frac{1}{\cos \theta \cot \varphi - \sin \theta \tan \theta \tan \varphi} \right\} \qquad (2)$$

Letting $OP = S$, as in Fig. A, then $FB = S/2 \cdot \cot \phi$. Substitute this value of FB in Eq. 2, then

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$$MN = R = S\left\{\frac{1}{\cos\theta - \sin\theta\tan\theta\tan^2\varphi}\right\} \quad (3)$$

Fig. 1 represents the same instrument directed upon a rod M_1N_1 supposed to be held in a vertical position, but which really is inclined to the vertical by some angle α, away from the instrument, the line of collimation assuming a vertical angle above the horizon.

The middle stadia wire being directed upon a fixed point on the rod (height of instrument), the line of collimation which, were the rod vertical should make an angle θ with the horizon, becomes depressed by some small angle β_1, and the resulting vertical angle becomes equal to $\theta - \beta_1 = \theta_1$, which is the vertical angle recorded in the field.

From T as center, with a radius $TB = h =$ height of instrument, draw an arc cutting M_1N_1 in a point B_1. The line AB_1 marks the new position of the line of collimation of the instrument.

From $\Delta M_1F_1B_1$,

$$M_1B_1 = F_1B_1\left\{\frac{\sin\varphi}{\sin[\pi/2 + (\theta_1 + \alpha - \varphi)]}\right\}$$

From $\Delta B_1F_1N_1$,

$$B_1N_1 = F_1B_1\left\{\frac{\sin\varphi}{\sin[\pi/2 - (\theta_1 + \alpha + \varphi)]}\right\}$$

$$\therefore M_1B_1 + B_1N_1 = M_1N_1$$

$$= F_1B_1\sin\varphi\left\{\frac{1}{\cos(\theta_1 + \alpha - \varphi)} + \frac{1}{\cos(\theta_1 + \alpha + \varphi)}\right\}$$

$$= F_1B_1\sin\varphi\left\{\frac{\cos[(\theta_1 + \alpha) + \varphi] + \cos[(\theta_1 + \alpha) - \varphi]}{\cos[(\theta_1 + \alpha) + \varphi]\cos[(\theta_1 + \alpha) - \varphi]}\right\}$$

$$= F_1B_1\sin\varphi\left\{\frac{2\cos(\theta_1 + \alpha)\cos\varphi}{\cos^2(\theta_1 + \alpha)\cos^2\varphi - \sin^2(\theta_1 + \alpha)\sin^2\varphi}\right\}$$

$$= 2F_1B_1\left\{\frac{1}{\cos(\theta_1+\alpha)\cot\varphi - \sin(\theta_1+\alpha)\tan(\theta_1+\alpha)\tan\varphi}\right\} \quad (4)$$

From A as center, with a radius AB draw an arc cutting AB_1 in a point Q_1. Join B and Q_1, also B and B_1. The triangle BQ_1B_1 results.

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From ΔBQ_1B_1, $Q_1B_1 = BB_1 \left\{ \frac{\sin [\pi/2-(\theta_1+\alpha/2+\beta_1/2)]}{\sin [\pi/2+\beta_1/2]} \right\}$

$$= \left\{ \frac{\cos (\theta_1+\alpha/2+\beta_1/2)}{\cos \beta_1/2} \right\}$$

From ΔBTB_1; $BB_1 = 2h \sin \alpha/2$.

$$\therefore Q_1B_1 = 2h \sin \alpha/2 \cos (\theta_1+\alpha/2+\beta_1/2) \sec \beta_1/2$$

Now $F_1B_1 = FB + Q_1B_1$, and $FB = S/2 \cdot \cot \phi$ (from Fig. B).

$$\therefore F_1B_1 = S/2 \cdot \cot \phi + 2h \sin \alpha/2 \cos (\theta_1+\alpha/2+\beta_1/2) \sec \beta_1/2$$

Substitute this value of F_1B_1 in equation 4, then

$$M_1N_1 = R_1 = \frac{S+4h \sin \alpha/2 \tan \varphi \cos (\theta_1+\alpha/2+\beta_1/2) \sec \beta_1/2}{\cos (\theta_1+\alpha) - \sin (\theta_1+\alpha) \tan (\theta_1+\alpha) \tan^2 \varphi} \quad (5)$$

Fig. 2 represents conditions as in Fig. 1, except that the stadia rod is tipped toward the instrument, the angle of inclination to the vertical remaining the same, and equal to α. For reasons given before the line of collimation of the instrument rises through some small angle β_2 and the vertical angle θ becomes equal to $\theta + \beta_2 = \theta_2$. AB_2 marks the new position of the line of collimation, and $TB = TB_2 = h$.

From $\Delta M_2F_2B_2$,

$$M_2B_2 = F_2B_2 \left\{ \frac{\sin \varphi}{\sin [\pi/2 + (\theta_2 - \alpha - \varphi)]} \right\}$$

From $\Delta B_2F_2N_2$,

$$B_2N_2 = F_2B_2 \left\{ \frac{\sin \varphi}{\sin [\pi/2 - (\theta_2 - \alpha + \varphi)]} \right\}$$

$$\therefore M_2B_2 + B_2N_2 = M_2N_2$$

$$= F_2B_2 \sin \varphi \left\{ \frac{1}{\cos (\theta_2 - \alpha - \varphi)} + \frac{1}{\cos (\theta_2 - \alpha + \varphi)} \right\}$$

$$= F_2B_2 \sin \varphi \left\{ \frac{\cos [(\theta_2 - \alpha) + \varphi] + \cos [(\theta_2 - \alpha) - \varphi]}{\cos [(\theta_2 - \alpha) - \varphi] \cos [(\theta_2 - \alpha) + \varphi]} \right\}$$

$$= F_2B_2 \sin \varphi \left\{ \frac{2 \cos (\theta_2 - \alpha) \cos \varphi}{\cos^2 (\theta_2 - \alpha) \cos^2 \varphi - \sin^2 (\theta_2 - \alpha) \sin^2 \varphi} \right\}$$

$$= F_2B_2 \left\{ \frac{1}{\cos (\theta_2 - \alpha) \cot \varphi - \sin (\theta_2 - \alpha) \tan (\theta_2 - \alpha) \tan \varphi} \right\} \quad (6)$$

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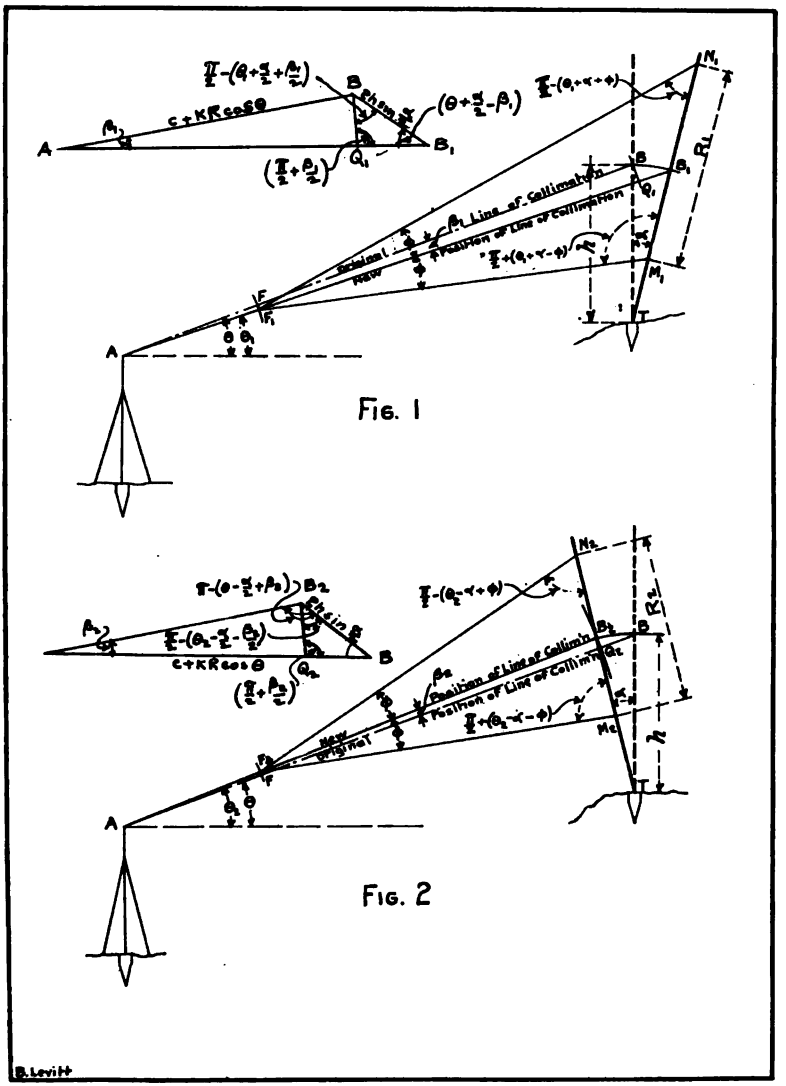

FIG. 1

FIG. 2

B. Levitt

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From A as center, with a radius AB_2, draw an arc cutting AB in a point Q_2. Join B_2 and Q_2, also B and B_2. The triangle BQ_2B_2 results.

From ΔBQ_2B_2, $Q_2B = BB_2 \left\{ \frac{\sin [\pi/2 - (\theta_2 - \alpha/2 - \beta_2/2)]}{\sin [\pi/2 + \beta_2/2]} \right\}$

From ΔBTB_2; $BB_2 = 2h \sin \alpha/2$.

$$\therefore Q_2B = 2h \sin \alpha/2 \cos (\theta_2 - \alpha/2 - \beta_2/2) \sec \beta_2/2$$

Now $F_2B_2 = FB - Q_2B$ and $FB = S/2 \cdot \cot \phi$.

$$\therefore F_2B_2 = S/2 \cdot \cot \phi - 2h \sin \alpha/2 \cos (\theta_2 - \alpha/2 - \beta_2/2) \sec \beta_2/2$$

Substitute the above value of F_2B_2 in equation 6, then

$$M_2N_2 = R_2 = \frac{S - 4h \sin \alpha/2 \tan \varphi \cos (\theta_2 - \alpha/2 - \beta_2/2) \sec \beta_2/2}{\cos (\theta_2 - \alpha) - \sin (\theta_2 - \alpha) \tan (\theta_2 - \alpha) \tan^2 \varphi} \quad (7)$$

Fig. 3 represents conditions when the line of collimation assumes a vertical angle below the horizon, and the stadia rod is tipped away from the instrument, the angle of inclination to the vertical being as before equal to α. The line of collimation rises through some angle β_3 and the vertical angle becomes equal to $\theta - \beta_3 = \theta_3$. AB_3 marks the new position of the line of collimation, and $TB = TB_3 = h$.

From $\Delta M_3F_3B_3$,

$$M_3B_3 = F_3B_3 \left\{ \frac{\sin \varphi}{\sin [\pi/2 - (\theta_3 - \alpha + \varphi)]} \right\}$$

From $\Delta B_3F_3N_3$,

$$B_3N_3 = F_3B_3 \left\{ \frac{\sin \varphi}{\sin [\pi/2 + (\theta_3 - \alpha - \varphi)]} \right\}$$

$$\therefore M_3B_3 + B_3N_3 = M_3N_3$$

$$= F_3B_3 \sin \varphi \left\{ \frac{1}{\cos (\theta_3 - \alpha + \varphi)} + \frac{1}{\cos (\theta_3 - \alpha - \varphi)} \right\}$$

$$= F_3B_3 \sin \varphi \left\{ \frac{\cos [(\theta_3 - \alpha) - \varphi] + \cos [(\theta_3 - \alpha) + \varphi]}{\cos [(\theta_3 - \alpha) + \varphi] \cos [(\theta_3 - \alpha) - \varphi]} \right\}$$

$$= F_3B_3 \sin \varphi \left\{ \frac{2 \cos (\theta_3 - \alpha) \cos \varphi}{\cos^2 (\theta_3 - \alpha) \cos^2 \varphi - \sin^2 (\theta_3 - \alpha) \sin^2 \varphi} \right\}$$

$$= 2F_3B_3 \left\{ \frac{1}{\cos (\theta_3 - \alpha) \cot \varphi - \sin (\theta_3 - \alpha) \tan (\theta_3 - \alpha) \tan \varphi} \right\} \quad (8)$$

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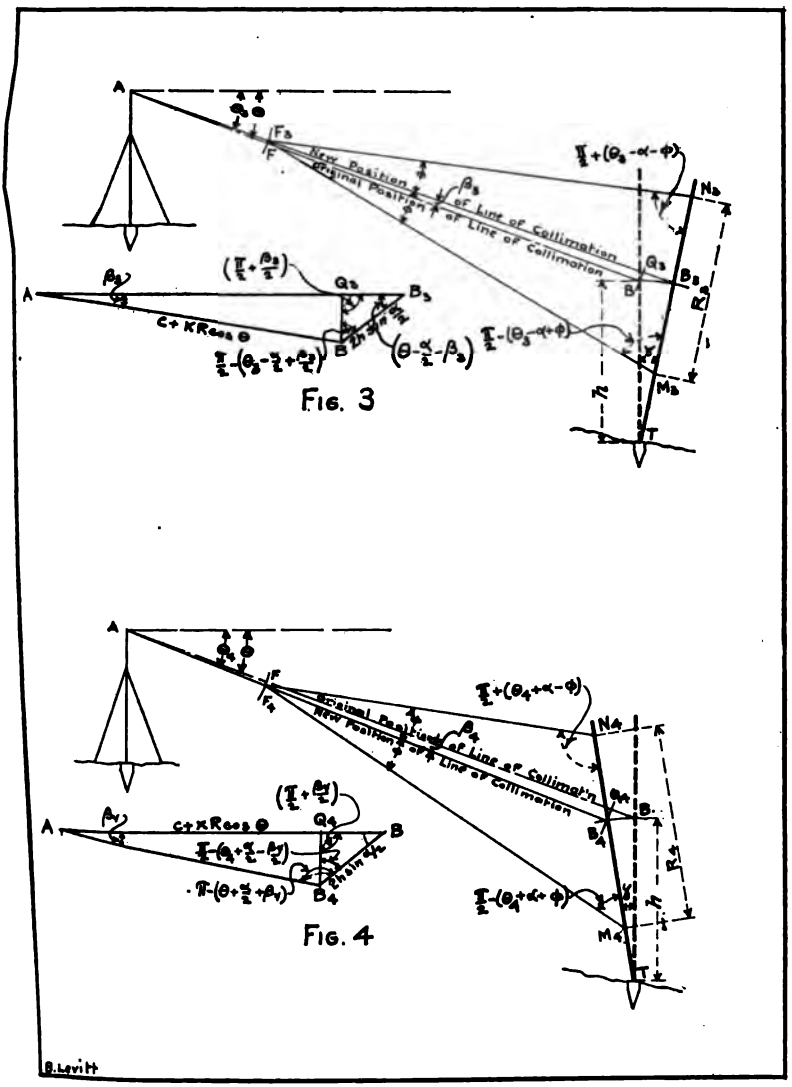

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From A as center, with a radius AB, draw an arc cutting AB_3 in a point Q_3. Join B and Q_3, also B and B_3. The triangle BQ_3B_3 results.

$$\text{From } \Delta BQ_3B_3,\ Q_3B_3 = BB_3\left\{\frac{\sin\left[\pi/2-(\theta_3-\alpha/2+\beta_3/2)\right]}{\sin\left[\pi/2+\beta_3/2\right]}\right\}$$

From ΔBTB_3; $BB_3 = 2h\ \sin \alpha/2$.

$$\therefore Q_3B_3 = 2h \sin \alpha/2 \cos(\theta_3 - \alpha/2 + \beta_3/2) \sec \beta_3/2$$

Now $F_3B_3 = FB + Q_3B_3$, and $FB = S/2 \cdot \cot \phi$.

$$\therefore F_3B_3 = S/2 \cdot \cot \phi + 2h \sin \alpha/2 \cos(\theta_3 - \alpha/2 + \beta_3/2) \sec \beta_3/2$$

Substitute the above value of F_3B_3 in equation 8, then

$$M_3N_3 = R_3 = \frac{S + 4h \sin \alpha/2 \tan \varphi \cos(\theta_3 - \alpha/2 + \beta_3/2) \sec \beta_3/2}{\cos(\theta_3 - \alpha) - \sin(\theta_3 - \alpha)\tan(\theta_3 - \alpha)\tan^2 \varphi} \quad (9)$$

Fig. 4 represents conditions as in Fig. 3, except that the stadia rod is tipped toward the instrument, the angle of inclination to the vertical remaining as before equal to α. The line of collimation becomes depressed by some small angle β_4 and the vertical angle becomes equal to $\theta + \beta_4 = \theta_4$. AB_4 marks the new position of the line of collimation, $TB = TB_4 = h$.

From $\Delta M_4F_4B_4$,

$$M_4B_4 = F_4B_4\left\{\frac{\sin \varphi}{\sin\left[\pi/2-(\theta_4+\alpha+\varphi)\right]}\right\}$$

From $\Delta B_4F_4N_4$

$$B_4N_4 = F_4B_4\left\{\frac{\sin \varphi}{\sin\left[\pi/2+(\theta_4+\alpha-\varphi)\right]}\right\}$$

$$\therefore M_4B_4 + B_4N_4 = M_4N_4$$

$$= F_4B_4 \sin \varphi \left\{\frac{1}{\cos(\theta_4+\alpha+\varphi)} + \frac{1}{\cos(\theta_4+\alpha-\varphi)}\right\}$$

$$= F_4B_4 \sin \varphi \left\{\frac{\cos[(\theta_4+\alpha)-\varphi] + \cos[(\theta_4+\alpha)+\varphi]}{\cos[(\theta_4+\alpha)+\varphi]\cos[(\theta_4+\alpha)-\varphi]}\right\}$$

$$= F_4B_4 \sin \varphi \left\{\frac{2\cos(\theta_4+\alpha)\cos\varphi}{\cos^2(\theta_4+\alpha)\cos^2\varphi - \sin^2(\theta_4+\alpha)\sin^2\varphi}\right\}$$

$$= 2F_4B_4\left\{\frac{1}{\cos(\theta_4+\alpha)\cot\varphi - \sin(\theta_4+\alpha)\tan(\theta_4+\alpha)\tan\varphi}\right\} \quad (10)$$

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From A as center with a radius AB_4 draw an arc cutting AB in a point Q_4. Join B_4 and Q_4, also B and B_4. The triangle BQ_4B_4 results.

$$\text{From } \Delta BQ_4B_4,\ Q_4B = BB_4\left\{\frac{\sin\left[\pi/2-(\theta_4+\alpha/2-\beta_4/2)\right]}{\sin\left[\pi/2+\beta_4/2\right]}\right\}$$

From ΔBTB_4; $BB_4 = 2h \sin \alpha/2$.

$$\therefore Q_4B = 2h \sin \alpha/2 \cos(\theta_4+\alpha/2-\beta_4/2) \sec \beta_4/2$$

Now $F_4B_4 = FB - Q_4B$ and $FB = S/2 \cdot \cot\phi$.

$$\therefore F_4B_4 = S/2 \cdot \cot\phi - 2h \sin \alpha/2 \cos(\theta_4+\alpha/2-\beta_4/2) \sec \beta_4/2$$

Substitute the above value of F_4B_4 in equation 10, then

$$M_4N_4 = R_4 = \frac{S-4h \sin \alpha/2 \tan\varphi \cos(\theta_4+\alpha/2-\beta_4/2) \sec \beta_4/2}{\cos(\theta_4+\alpha) - \sin(\theta_4+\alpha)\tan(\theta_4+\alpha)\tan^2\varphi} \quad (11)$$

Intercepts.

The values of R given by equations 3, 5, 7, 9 and 11 represent the intercepts on the stadia rod, for the different conditions represented by the diagrams, in terms of the intercept S (Fig. B).

From equation 3,

$$S = R\cos\theta - R\sin\theta\tan\theta\tan^2\phi \quad (12)$$

Substitute the value of S given by equation 12 in equations 5, 7, 9 and 11, then

$$R_1 = \frac{R\cos\theta - R\sin\theta\tan\theta\tan^2\varphi + 4h\sin\alpha/2\tan\varphi\cos(\theta_1+\alpha/2+\beta_1/2)\sec\beta_1/2}{\cos(\theta_1+\alpha) - \sin(\theta_1+\alpha)\tan(\theta_1+\alpha)\tan^2\varphi} \quad (13)$$

$$R_2 = \frac{R\cos\theta - R\sin\theta\tan\theta\tan^2\varphi - 4h\sin\alpha/2\tan\varphi\cos(\theta_2-\alpha/2-\beta_2/2)\sec\beta_2/2}{\cos(\theta_2-\alpha) - \sin(\theta_2-\alpha)\tan(\theta_2-\alpha)\tan^2\varphi} \quad (14)$$

$$R_3 = \frac{R\cos\theta - R\sin\theta\tan\theta\tan^2\varphi + 4h\sin\alpha/2\tan\varphi\cos(\theta_3-\alpha/2+\beta_3/2)\sec\beta_3/2}{\cos(\theta_3-\alpha) - \sin(\theta_3-\alpha)\tan(\theta_3-\alpha)\tan^2\varphi} \quad (15)$$

$$R_4 = \frac{R\cos\theta - R\sin\theta\tan\theta\tan^2\varphi - 4h\sin\alpha/2\tan\varphi\cos(\theta_4+\alpha/2-\beta_4/2)\sec\beta_4/2}{\cos(\theta_4+\alpha) - \sin(\theta_4+\alpha)\tan(\theta_4+\alpha)\tan^2\varphi} \quad (16)$$

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General Equations.

Substituting the value of S given by equation 12 in equation 1, the general equation for the inclined distance for any value of R becomes,

$$D = C + kR\cos\theta - kR\sin\theta\tan\theta\tan^2\phi \qquad (17)$$

The horizontal and vertical distances are obtained by multiplying equation 17 by cos θ and sin θ respectively.

Denoting the horizontal distance by H, and the vertical by V, the equations are:

$$H = C\cos\theta + kR\cos^2\theta - kR\cos\theta\sin\theta\tan\theta\tan^2\phi$$

$$V = C\sin\theta + kR\sin\theta\cos\theta - kR\sin^2\theta\tan\theta\tan^2\phi$$

In the preparation of stadia reduction tables the terms involving $\tan^2\phi$ in the above equations are neglected, their value being too small to affect the result. This is equivalent to the assumption that the rays proceeding from the principal focus F become normal to the stadia rod at the point where they impinge upon the rod.

Neglecting the terms involving $\tan^2\phi$, the equations are

$$H = C\cos\theta + kR\cos^2\theta \qquad (18)$$

$$V = C\sin\theta + kR\cdot(\sin 2\theta)/2 \qquad (19)$$

Substituting the values of R given by equations 13, 14, 15 and 16, in equations 18 and 19, remembering at the same time that the values of θ in equations 18 and 19 change to θ_1, θ_2, θ_3 and θ_4 to correspond with the subscripts of R, also neglecting all terms involving $\tan^2\phi$, the equations for horizontal and vertical distances will be obtained, each of which will be in error due to the rod not being held in a vertical position, for which position alone the rod is assumed to have been graduated and readings from it correct.

The horizontal and vertical distances will be given by the following equations.

$H = C\cos\theta + kR\cos^2\theta$ Correct distance.

$$H_1 = C\cos\theta_1 + kR\cos\theta\frac{\cos^2\theta_1}{\cos(\theta_1+\alpha)} + \frac{4kh\sin\alpha/2\cdot\tan\varphi\cos^2\theta_1\cos(\theta_1+\alpha/2+\beta_1/2)\sec\beta_1/2}{\cos(\theta_1+\alpha)}$$

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$$H_2 = C\cos\theta_2 + kR\cos\theta\frac{\cos^2\theta_2}{\cos(\theta_2-\alpha)} - \frac{4kh\sin\alpha/2\tan\varphi\cos^2\theta_2\cos(\theta_2-\alpha/2-\beta_2/2)\sec\beta_2/2}{\cos(\theta_2-\alpha)}$$

$$H_3 = C\cos\theta_3 + kR\cos\theta\frac{\cos^2\theta_3}{\cos(\theta_3-\alpha)} + \frac{4kh\sin\alpha/2\tan\varphi\cos^2\theta_3\cos(\theta_3-\alpha/2+\beta_3/2)\sec\beta_3/2}{\cos(\theta_3-\alpha)}$$

$$H_4 = C\cos\theta_4 + kR\cos\theta\frac{\cos^2\theta_4}{\cos(\theta_4+\alpha)} - \frac{4kh\sin\alpha/2\tan\varphi\cos^2\theta_4\cos(\theta_4+\alpha/2-\beta_4/2)\sec\beta_4/2}{\cos(\theta_4+\alpha)}$$

$$V = C\sin\theta + kR\frac{\sin 2\theta}{2} \qquad \text{Correct distance.}$$

$$V_1 = C\sin\theta_1 + kR\cos\theta\frac{\sin 2\theta_1}{2\cos(\theta_1+\alpha)} + \frac{2kh\sin\alpha/2\tan\varphi\sin 2\theta_1\cos(\theta_1+\alpha/2+\beta_1/2)\sec\beta_1/2}{\cos(\theta_1+\alpha)}$$

$$V_2 = C\sin\theta_2 + kR\cos\theta\frac{\sin 2\theta_2}{2\cos(\theta_2-\alpha)} - \frac{2kh\sin\alpha/2\tan\varphi\sin 2\theta_2\cos(\theta_2-\alpha/2-\beta_2/2)\sec\beta_2/2}{\cos(\theta_2-\alpha)}$$

$$V_3 = C\sin\theta_3 + kR\cos\theta\frac{\sin 2\theta_3}{2\cos(\theta_3-\alpha)} + \frac{2kh\sin\alpha/2\tan\varphi\sin 2\theta_3\cos(\theta_3-\alpha/2+\beta_3/2)\sec\beta_3/2}{\cos(\theta_3-\alpha)}$$

$$V_4 = C\sin\theta_4 + kR\cos\theta\frac{\sin 2\theta_4}{2\cos(\theta_4+\alpha)} - \frac{2kh\sin\alpha/2\tan\varphi\sin 2\theta_4\cos(\theta_4+\alpha/2-\beta_4/2)\sec\beta_4/2}{\cos(\theta_4+\alpha)}$$

Since $\theta_1 = \theta - \beta_1$; $\theta_2 = \theta + \beta_2$; $\theta_3 = \theta - \beta_3$; $\theta_4 = \theta + \beta_4$, the above equations may be written as follows

$$H = C\cos\theta + kR\cos^2\theta \qquad \text{Correct distance.}$$

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$$H_1 = C\cos(\theta-\beta_1) + kR\cos\theta\frac{\cos^2(\theta-\beta_1)}{\cos(\theta+\alpha-\beta_1)}$$
$$+4kh\sin\alpha/2\tan\varphi\frac{\cos^2(\theta-\beta_1)\cos(\theta+\alpha/2-\beta_1/2)}{\cos(\theta+\alpha-\beta_1)\cos\beta_1/2}$$

$$H_2 = C\cos(\theta+\beta_2) + kR\cos\theta\frac{\cos^2(\theta+\beta_2)}{\cos(\theta-\alpha+\beta_2)}$$
$$-4kh\sin\alpha/2\tan\varphi\frac{\cos^2(\theta+\beta_2)\cos(\theta-\alpha/2+\beta_2/2)}{\cos(\theta-\alpha+\beta_2)\cos\beta_2/2}$$

$$H_3 = C\cos(\theta-\beta_3) + kR\cos\theta\frac{\cos^2(\theta-\beta_3)}{\cos(\theta-\alpha-\beta_3)}$$
$$+4kh\sin\alpha/2\tan\varphi\frac{\cos^2(\theta-\beta_3)\cos(\theta-\alpha/2-\beta_3/2)}{\cos(\theta-\alpha-\beta_3)\cos\beta_3/2}$$

$$H_4 = C\cos(\theta+\beta_4) + kR\cos\theta\frac{\cos^2(\theta+\beta_4)}{\cos(\theta+\alpha+\beta_4)}$$
$$-4kh\sin\alpha/2\tan\varphi\frac{\cos(\theta+\beta_4)\cos(\theta+\alpha/2+\beta_4/2)}{\cos(\theta+\alpha+\beta_4)\cos\beta_4/2}$$

$$V = C\sin\theta + kR\frac{\sin 2\theta}{2} \qquad \text{Correct distance.}$$

$$V_1 = C\sin(\theta-\beta_1) + kR\cos\theta\frac{\sin 2(\theta-\beta_1)}{2\cos(\theta+\alpha-\beta_1)}$$
$$+2kh\sin\alpha/2\tan\varphi\frac{\sin 2(\theta-\beta_1)\cos(\theta+\alpha/2-\beta_1/2)}{\cos(\theta+\alpha-\beta_1)\cos\beta_1/2}$$

$$V_2 = C\sin(\theta+\beta_2) + kR\cos\theta\frac{\sin 2(\theta+\beta_2)}{2\cos(\theta-\alpha+\beta_2)}$$
$$-2kh\sin\alpha/2\tan\varphi\frac{\sin 2(\theta+\beta_2)\cos(\theta-\alpha/2+\beta_2/2)}{\cos(\theta-\alpha+\beta_2)\cos\beta_2}$$

$$V_3 = C\sin(\theta-\beta_3) + kR\cos\theta\frac{\sin 2(\theta-\beta_3)}{2\cos(\theta-\alpha-\beta_3)}$$
$$+2kh\sin\alpha/2\tan\varphi\frac{\sin 2(\theta-\beta_3)\cos(\theta-\alpha/2-\beta_3/2)}{\cos(\theta-\alpha-\beta_3)\cos\beta_3/2}$$

$$V_4 = C\sin(\theta+\beta_4) + kR\cos\theta\frac{\sin 2(\theta+\beta_4)}{2\cos(\theta+\alpha+\beta_4)}$$
$$-2kh\sin\alpha/2\tan\varphi\frac{\sin 2(\theta+\beta_4)\cos(\theta+\alpha/2+\beta_4/2)}{\cos(\theta+\alpha+\beta_4)\cos\beta_4/2}$$

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Errors.

The errors in the reduced horizontal and vertical distances will be

	Horizontal Distances.	Vertical Distances.
$E_1 =$	$H_1 - H$	$V_1 - V$
$E_2 =$	$H_2 - H$	$V_2 - V$
$E_3 =$	$H_3 - H$	$V_3 - V$
$E_4 =$	$H_4 - H$	$V_4 - V$

The errors E_1, E_2, E_3 and E_4 for both horizontal and vertical distances were computed and are tabulated in Tables I. and II., for various values of θ and α.

The values of β_1, β_2, β_3 and β_4 are too small to have any effect on the reduced distances, and as they diminish very rapidly as R increases, they were disregarded in the computation of the tabulated values of E; their own values, however, for $R = 1$ foot were computed and are tabulated in Table III.

The equations for E neglecting β become,

Horizontal Distances.

$$E_1 = kR\left(\frac{\cos^3\theta}{\cos(\theta+\alpha)} - \cos^2\theta\right) + 4kh\sin\frac{\alpha}{2}\tan\varphi\cos^2\theta\frac{\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$$

$$E_2 = kR\left(\frac{\cos^3\theta}{\cos(\theta-\alpha)} - \cos^2\theta\right) - 4kh\sin\frac{\alpha}{2}\tan\varphi\cos^2\theta\frac{\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$$

$$E_3 = kR\left(\frac{\cos^3\theta}{\cos(\theta-\alpha)} - \cos^2\theta\right) + 4kh\sin\frac{\alpha}{2}\tan\varphi\cos^2\theta\frac{\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$$

$$E_4 = kR\left(\frac{\cos^3\theta}{\cos(\theta+\alpha)} - \cos^2\theta\right) - 4kh\sin\frac{\alpha}{2}\tan\varphi\cos^2\theta\frac{\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$$

Vertical Distances.

$$E_1 = \tfrac{1}{2}kR\left(\frac{\cos\theta\sin 2\theta}{\cos(\theta+\alpha)} - \sin 2\theta\right) + 2kh\sin\frac{\alpha}{2}\tan\varphi\sin 2\theta\frac{\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$$

$$E_2 = \tfrac{1}{2}kR\left(\frac{\cos\theta\sin 2\theta}{\cos(\theta-\alpha)} - \sin 2\theta\right) - 2kh\sin\frac{\alpha}{2}\tan\varphi\sin 2\theta\frac{\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$$

$$E_3 = \tfrac{1}{2}kR\left(\frac{\cos\theta\sin 2\theta}{\cos(\theta-\alpha)} - \sin 2\theta\right) + 2kh\sin\frac{\alpha}{2}\tan\varphi\sin 2\theta\frac{\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$$

$$E_4 = \tfrac{1}{2}kR\left(\frac{\cos\theta\sin 2\theta}{\cos(\theta+\alpha)} - \sin 2\theta\right) - 2kh\sin\frac{\alpha}{2}\tan\varphi\sin 2\theta\frac{\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$$

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It will be noted, in the above equations, that the first term varies directly with R, and that the second term is constant for all values of R; also that the two terms in E_1 and E_4, and in E_2 and E_3, are alike except for the second term, having opposite signs.

In the following tables the two terms of the equations are tabulated separately and the sum of the two terms, paying attention to the proper signs, will give the values of E.

In the computation of the tables the following constants were assumed.

h = height of instrument, (H.I.) 5 feet.
k = instrument constant, 100.
R = intercept on the rod, 1 foot.

The errors for any distance other than that given by $R = 1$ foot may be obtained by multiplying the values of the term involving R by the proper ratio, the constant remaining unchanged.

In Table III., the values of β vary, very nearly, inversely with the value of R.

The Tables I., II. and III. give the values of E and β for rod readings of 100 feet and mean that, barring all other sources of errors, the true values of the vertical angles and reduced horizontal and vertical distances will be too small or too large, as the case may be, by the amounts tabulated for rod inclinations at various angles.

Values of β.

Fig. 1.

From ΔABB_1

$$\frac{C + kR\cos\theta}{2h\sin a/2} = \frac{\sin[(\theta + a/2) - \beta_1]}{\sin\beta_1}$$

$$\frac{\sin[(\theta + a/2) - \beta_1]}{\sin\beta_1} = \sin(\theta + a/2)\cot\beta_1 - \cos(\theta + a/2)$$

$$\therefore \cot\beta_1 = \frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta + a/2)} + \cot(\theta + a/2)$$

and

$$\beta_1 = \cot^{-1}\left\{\frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta + a/2)} + \cot(\theta + a/2)\right\}$$

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Fig. 2.

From ΔABB_2

$$\frac{C + kR\cos\theta}{2h\sin a/2} = \frac{\sin[(\theta - a/2) + \beta_2]}{\sin\beta_2}$$

$$\frac{\sin[(\theta - a/2) + \beta_2]}{\sin\beta_2} = \sin(\theta - a/2)\cot\beta_2 + \cos(\theta - a/2)$$

$$\therefore \cot\beta_2 = \frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta - a/2)} - \cot(\theta - a/2)$$

and

$$\beta_2 = \cot^{-1}\left\{\frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta - a/2)} - \cot(\theta - a/2)\right\}$$

Fig. 3.

From ΔABB_3

$$\frac{C + kR\cos\theta}{2h\sin a/2} = \frac{\sin[(\theta - a/2) - \beta_3]}{\sin\beta_3}$$

$$\frac{\sin[(\theta - a/2) - \beta_3]}{\sin\beta_3} = \sin(\theta - a/2)\cot\beta_2 - \cos(\theta - a/2)$$

$$\therefore \cot\beta_3 = \frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta - a/2)} + \cot(\theta - a/2)$$

and

$$\beta_3 = \cot^{-1}\left\{\frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta - a/2)} + \cot(\theta - a/2)\right\}$$

Fig. 4.

From ΔABB_4

$$\frac{C + kR\cos\theta}{2h\sin a/2} = \frac{\sin[(\theta + a/2) + \beta_4]}{\sin\beta_4}$$

$$\frac{\sin[(\theta + a/2) + \beta_4]}{\sin\beta_4} = \sin(\theta + a/2)\cot\beta_4 + \cos(\theta + a/2)$$

$$\therefore \cot\beta_4 = \frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta + a/2)} - \cot(\theta + a/2)$$

and

$$\beta_4 = \cot^{-1}\left\{\frac{C + kR\cos\theta}{2h\sin a/2\sin(\theta + a/2)} - \cot(\theta + a/2)\right\}$$

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TABLE I.

VALUES OF E FOR HORIZONTAL DISTANCES (IN FEET).

Values of α	For H_1 and H_3 — Excess in Distance — Variable $kR\left\{\frac{\cos^2\theta}{\cos(\theta+\alpha)}-\cos^2\theta\right\}$ — Values of θ							For H_1 and H_3 — Excess in Distance — Constant (±) $4kh\sin\frac{\alpha}{2}\tan\phi\frac{\cos^2\theta\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$ — Values of θ							For H_2 and H_4 — Reduction in Distance — Variable $kR\left\{\frac{\cos^2\theta}{\cos(\theta-\alpha)}-\cos^2\theta\right\}$ — Values of θ							For H_2 and H_4 — Reduction in Distance — Constant (±) $4kh\sin\frac{\alpha}{2}\tan\phi\frac{\cos^2\theta\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$ — Values of θ						
	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°
1°	.015	.167	.314	.453	.578	.687	.775	.087	.087	.085	.082	.077	.072	.066	.015	.136	.287	.420	.544	.650	.737	.087	.086	.084	.081	.077	.071	.065
2	.060	.365	.660	.939	1.192	1.411	1.590	.175	.173	.170	.164	.155	.145	.132	.060	.242	.535	.808	1.060	1.266	1.437	.175	.173	.169	.162	.153	.142	.130
3	.140	.594	1.039	1.459	1.841	2.174	2.446	.262	.260	.255	.246	.234	.218	.200	.140	.317	.757	1.165	1.534	1.849	2.103	.262	.259	.253	.243	.229	.213	.194
4	.240	.850	1.450	2.014	2.528	2.976	3.346	.350	.348	.341	.329	.313	.292	.268	.240	.362	.948	1.492	1.981	2.399	2.734	.350	.346	.337	.323	.305	.283	.257
5	.380	1.150	1.896	2.605	3.253	3.821	4.292	.437	.436	.428	.413	.393	.367	.337	.380	.377	1.109	1.789	2.398	2.918	3.334	.437	.432	.421	.403	.380	.352	.320
6	.550	1.470	2.375	3.233	4.018	4.709	5.285	.525	.524	.514	.497	.473	.443	.407	.550	.362	1.241	2.055	2.785	3.406	3.901	.525	.519	.505	.484	.455	.421	.383
7	.750	1.830	2.890	3.899	4.825	5.643	6.319	.614	.613	.602	.582	.555	.520	.478	.750	.317	1.343	2.293	3.142	3.864	4.429	.614	.606	.589	.564	.530	.490	.445
8	.980	2.220	3.445	4.604	5.675	6.625	7.425	.703	.702	.690	.668	.637	.598	.550	.980	.242	1.416	2.502	3.471	4.294	4.947	.703	.693	.673	.644	.605	.559	.507
9	1.250	2.650	4.025	5.350	6.570	7.656	8.577	.792	.791	.779	.755	.721	.677	.624	1.250	.136	1.459	2.682	3.772	4.695	5.427	.792	.781	.758	.724	.680	.628	.569
10	1.540	3.110	4.655	6.138	7.512	8.740	9.789	.882	.882	.869	.843	.806	.757	.699	1.540	0	1.474	2.835	4.045	5.069	5.880	.882	.868	.842	.804	.755	.696	.630

Assumed $kR = 100$ feet; $h = 5$ feet.

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TABLE II.

VALUES OF E FOR VERTICAL DISTANCES (IN FEET).

Values of α	For V_1 and V_3 — Excess in Distance — Variable: $\frac{1}{2}kR\left\{\frac{\cos\theta\sin 2\theta}{\cos(\theta+\alpha)}-\sin 2\theta\right\}$ — Values of θ							For V_1 and V_3 — Excess in Distance — Constant (±): $2kh\sin\frac{\alpha}{2}\tan\phi\,\frac{\sin 2\theta\cos(\theta+\alpha/2)}{\cos(\theta+\alpha)}$ — Values of θ							For V_2 and V_4 — Reduction in Distance — Variable: $\frac{1}{2}kR\left\{\frac{\cos\theta\sin 2\theta}{\cos(\theta-\alpha)}-\sin 2\right\}$ — Values of θ							For V_2 and V_4 — Reduction in Distance — Constant (±): $2kh\sin\frac{\alpha}{2}\tan\phi\,\frac{\sin 2\theta\cos(\theta-\alpha/2)}{\cos(\theta-\alpha)}$ — Values of θ						
	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°
1°	0	.015	.055	.121	.211	.320	.448	0	.008	.015	.022	.028	.034	.038	0	.012	.050	.113	.198	.303	.425	0	.007	.015	.022	.028	.034	.038
2	0	.032	.116	.252	.434	.658	.918	0	.015	.030	.044	.056	.067	.076	0	.021	.094	.217	.384	.591	.830	0	.015	.030	.043	.056	.066	.075
3	0	.052	.183	.391	.670	1.014	1.413	0	.023	.045	.066	.085	.102	.115	0	.027	.133	.312	.558	.862	1.214	0	.023	.045	.065	.083	.099	.112
4	0	.075	.256	.540	.920	1.388	1.932	0	.030	.060	.088	.114	.136	.155	0	.031	.167	.400	.721	1.119	1.578	0	.030	.059	.087	.111	.132	.148
5	0	.101	.334	.698	1.184	1.782	2.478	0	.038	.075	.011	.143	.171	.194	0	.033	.195	.479	.873	1.361	1.924	0	.038	.074	.108	.138	.164	.185
6	0	.129	.419	.866	1.463	2.196	3.052	0	.046	.091	.133	.172	.206	.235	0	.031	.219	.551	1.013	1.589	2.252	0	.045	.089	.130	.166	.197	.221
7	0	.161	.510	1.045	1.757	2.631	3.654	0	.054	.106	.156	.202	.242	.276	0	.027	.237	.615	1.143	1.802	2.562	0	.053	.104	.151	.193	.229	.257
8	0	.195	.607	1.234	2.066	3.089	4.287	0	.061	.122	.179	.232	.279	.318	0	.021	.249	.671	1.263	2.002	2.856	0	.061	.119	.172	.220	.261	.293
9	0	.232	.711	1.433	2.392	3.570	4.952	0	.069	.137	.202	.262	.315	.360	0	.012	.257	.719	1.373	2.190	3.133	0	.068	.133	.194	.247	.293	.328
10	0	.272	.821	1.645	2.734	4.076	5.652	0	.077	.153	.226	.293	.353	.404	0	0	.260	.760	1.472	2.364	3.394	0	.076	.148	.215	.275	.325	.364

Assumed $kR = 100$ feet; $h = 5$ feet.

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TABLE III.

VALUES OF β IN MINUTES AND SECONDS.

Values of α	Values of β_1: $\beta_1 = \cot^{-1}\left\{\frac{C+kR\cos\theta}{2k\sin\alpha/2\sin(\theta+\alpha/2)} + \cot\left(\theta+\frac{\alpha}{2}\right)\right\}$							Values of β_2: $\beta_2 = \cot^{-1}\left\{\frac{C+kR\cos\theta}{2k\sin\alpha/2\sin(\theta-\alpha/2)} - \cot\left(\theta-\frac{\alpha}{2}\right)\right\}$							Values of β_3: $\beta_3 = \cot^{-1}\left\{\frac{C+kR\cos\theta}{2k\sin\alpha/2\sin(\theta-\alpha/2)} + \cot\left(\theta-\frac{\alpha}{2}\right)\right\}$							Values of β_4: $\beta_4 = \cot^{-1}\left\{\frac{C+kR\cos\theta}{2k\sin\alpha/2\sin(\theta+\alpha/2)} - \cot\left(\theta+\frac{\alpha}{2}\right)\right\}$						
	Values of θ							Values of θ							Values of θ							Values of θ						
	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°	0°	5°	10°	15°	20°	25°	30°
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
1°	0.02	0.17	0.33	0.49	1.06	1.25	1.44	0.02	0.14	0.30	0.46	1.03	1.21	1.41	0.02	0.14	0.30	0.46	1.03	1.21	1.41	0.02	0.17	0.33	0.49	1.06	1.25	1.44
2°	0.06	0.37	1.09	1.41	2.16	2.52	3.31	0.06	0.25	0.57	1.31	2.04	2.40	3.20	0.06	0.25	0.57	1.31	2.03	2.40	3.19	0.06	0.37	1.09	1.42	2.16	2.53	3.32
3°	0.14	1.01	1.48	2.37	3.28	4.22	5.21	0.14	0.33	1.20	2.09	3.01	3.56	4.55	0.14	0.33	1.20	2.09	3.00	3.54	4.53	0.14	1.01	1.48	2.37	3.29	4.24	5.23
4°	0.25	1.27	2.30	3.35	4.43	5.55	7.14	0.25	0.38	1.41	2.46	3.55	5.08	6.27	0.25	0.37	1.40	2.45	3.53	5.06	6.24	0.25	1.28	2.31	3.36	4.45	5.58	7.16
5°	0.39	1.56	3.15	4.36	6.01	7.31	9.10	0.39	0.39	1.58	3.20	4.46	6.17	7.56	0.39	0.39	1.58	3.19	4.44	6.14	7.52	0.39	1.57	3.17	4.38	6.04	7.35	9.14
6°	0.56	2.29	4.03	5.40	7.22	9.10	11.08	0.56	0.38	2.13	3.51	5.34	7.24	9.22	0.56	0.37	2.12	3.49	5.31	7.19	9.17	0.56	2.30	4.05	5.44	7.26	9.16	11.14
7°	1.16	3.04	4.54	6.47	8.46	10.52	13.09	1.17	0.33	2.24	4.19	6.19	8.27	10.45	1.16	0.33	2.23	4.16	6.14	8.21	10.23	1.17	3.06	4.57	6.52	8.52	11.00	13.18
8°	1.39	3.42	5.47	7.57	10.12	12.36	15.12	1.40	0.25	2.32	4.43	7.01	9.27	12.05	1.39	0.25	2.30	4.39	6.55	9.18	11.39	1.40	3.45	5.52	8.03	10.20	12.46	15.25
9°	2.05	4.23	6.44	9.09	11.41	14.23	17.19	2.07	0.14	2.37	5.05	7.39	10.24	13.22	2.05	0.14	2.35	5.00	7.32	10.14	13.09	2.07	4.27	6.50	9.18	11.52	14.36	17.34
10°	2.34	5.07	7.44	10.25	13.13	16.13	19.28	2.36	0	2.39	5.23	8.14	11.17	14.35	2.34	0	2.36	5.17	8.05	11.05	14.19	2.36	5.13	7.52	10.35	13.27	16.29	19.47

Assumed $kR = 100$ feet; $k = 5$ feet.

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THE PRINCIPLES OF BUSINESS MANAGEMENT OF AN ARCHITECT'S OFFICE PRACTICE.*

By H. S. KISSAM.

There are two important branches of this theme, both of which should be the subject of careful study as a necessary preparation for establishing a peaceful, profitable practice in architecture.

Neither branch is in a complete state of exact information, consequently judgment and experience, after learning the fundamental principles of them, must be one's guide for avoiding the ill results with which their misunderstanding may be attended.

These two branches are:

1. Architectural jurisprudence.
2. Office systems and organization.

I can say but a few words on the first of these as there is not time to go clearly into the subject, before taking up the principles of office systems, which latter, I have come here for the purpose of directing your attention to.

What the status is of an architect in the community is an unsettled vexatious question. The opinion of courts classify him, from a follower of a mercantile trade with customers, to a practitioner of a liberal profession with clients. All judicial opinions however, regard the architect as the head of all persons engaged in the building trade and expect of him high skill in designing, great care in conducting operations, and the highest good faith towards all parties.

His relation to the owner is generally that of agent to a principal, but it is not purely such as the condition of a trust also exists, for in performing his duties, his acts are of two distinct capacities—ministerial and quasi-judicial. His acts in the latter

* An address to the upper classmen in the Department of Architecture, School of Fine Arts of Columbia University, N. Y. C., April 28, 1908, by the President of the Society of Columbia University Architects. By courtesy of *The American Architect*.

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capacity which involve considerable discretion are held to be acts of trust. This you must bear in mind, for it is a rule that acts of trust cannot be delegated to third parties, but must be performed in person.

The architect's quasi-judicial act is an exercise of his professional opinion and judgment, and in such exercise he is accorded by the courts the same protection as a judge; that is to say, he cannot be called to answer for such before any judicial tribunal, presuming, of course, that his act was one of good faith.

As an example of quasi-judicial functions, I would mention the usual provision that the contractor's right to payment is made dependent upon the architect's approval of his work; that is a wide power and one in which the architect's decision is final.

As an example of ministerial functions I would mention the furnishing of contractors with drawings and instructions by which to work. You will realize that if the architect fails in any respect to furnish a contractor with information necessary for prosecuting work, he fails in a ministerial function for which he is liable and he cannot successfully place the burden of default on the contractor through exercising his quasi-judicial function of refusing a certificate of payment, because the work is not at a condition to receive his approval. He must right his own wrong and help the contractor if he would avoid censure from client and court.

These few preliminary remarks will serve to indicate to you the necessity of an architect's having some knowledge of architectural jurisprudence. If you desire to pursue the subject further, you will find many works on it in the Columbia University Library and many articles on it in the files of the architectural magazines. I refer you to the following books: T. M. Clark, "Architect, Owner and Builder Before the Law"; A. C. R. Emden, "Law Relating to Buildings"; A. P. Lloyd, "Treatise on the Law of Buildings"; J. A. Strahan, "Legal Position of Architects as to Certificates"; T. M. White, "Recent Legal Decisions Affecting Architects."

Now as to office systems and organization.

System and organization are the mechanism of profitable practice. System makes possible effective expedition in office work. Organization is the medium for applying the labor of the office economically.

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No practice may be conducted without begetting some amount of record. The reasonable multiplication of correlated record is a necessary safeguard against falling into a wasteful contentious practice.

Standardizing and systematizing all matter entering into record capable of being reduced to, and conducted under uniform forms of uniform sizes is to establish system. Forms are the elements of system.

An office organization has two branches, the executive and the productive. The executive is many things, but with respect to the productive branch it is preëminently the motive force for good organization, leading to attaining efficient action, checking against faulty or wasteful action.

The productive branch naturally divides itself into three general departments bound to each other by the executive. These are: *The drafting department*—concerned with designing buildings, making working drawings, furnishing printed copies of drawings; *the specification department*—concerned with writing specifications, taking estimates, letting contracts and having charge of catalogues and samples; *the construction department*—concerned with having work executed, certifying to payments and closing contracts.

It is common in large offices to organize an accounting department under the executive branch, with a subdivision having charge of records, files and supplies; then a ledger is kept having an account with each division and with the office in order to segregate the cost of each, and to enable keeping costs of each piece of work other than by approximations.

Such are the well-known divisions of office organization. I name them in detail because they must all be kept consciously in mind in devising forms for conducting the activities of any one of them; they are interrelated in so many respects. Further, it is most important that all forms should be devised with the view that the executive is to be the uniting link for connecting the activities of each division to each of the others.

Now to take up forms of systems in order of usefulness for a usual case of uneventful successful progress.

The first set would of course relate to being engaged to do work.

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The second set would relate to imitiating work. The third set would relate to carrying work to the stage of awarding a contract. The fourth set would relate to having the work conducted and concluded.

It would be impossible to give you sufficient information of the forms of each of these four steps in a short talk and it would be but of small help to you to give you copies of models of them, without also giving you directions concerning their uses. I will however show you copies of some of them, explain in sequence something of the purpose of the forms for these four simple conditions, and leave you to extend your information through obtaining from firms well known for their office systems, whom I will recommend to you, copies of the forms they use. Should your time and instructors approve, I suggest you confer with the Committee on Employment and Office Practice of the Society of Columbia University Architects, for coöperation in achieving the minimum number, or indispensable set of model forms suitable for a moderate sized practice.

The first and most important form is form in letter writing. Make the contents of your letters terse, clear and courteous; let no matter escape being written of promptly; confirm all conversations and messages by letter; acquaint all interested parties with each matter, as it arises, your disposal of which they have interest in.

The next important general form is in the use of numbers, labelling names, or of letters of the alphabet, for the segregation of matter. As a beginning, give a number to each piece of work you undertake and number work consecutively.

Correspondence is best filed by keeping all letters alphabetically arranged, in cabinets of boxes, each box labelled with the number of the piece of work the letters in it refer to. Place a carbon copy of each of your letters with the letter it answers or which answers it. Vertical cabinet files consisting of drawers into each of which the correspondence of a group of buildings is kept are coming now into common use.

Index your correspondence by name and by the number of the piece of work it is concerned with in a card catalogue drawer with the cards arranged alphabetically; enter on each card the

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writer's name and address a card to each name, and the name and the number of the piece of work he is concerned with. This links your correspondence to your work, for the set of indexes, one by name, the other by number and name of building, completes a cross reference.

This brings us to the consideration of the usual forms of the four stages of work, which I enumerated.

It should be borne in mind that a division into four stages is for the purpose of logical presentation through mentioning them at a time when they first come into usefulness, and that most of them continue to have application in one or more of the steps following their introduction.

The common forms of set one, relating to being engaged to do work are:

SET 1.

1. Slip for name and business of callers.....U. T.
2. Postal forms for asking or making engagements.....U. T.
3. Mem. blank for recording messages over the 'phone.....U. T.
4. Schedule of fees charged.
5. Form of agreement between architect and client.
6. Correspondence files.....U. T.
7. Card catalogue of correspondence.....U. T.
8. Information book or memo. record of instructions and talks..U. T.
9. Record of calls and visits; date, hour, name, asked for, saw, said.U. T.

The common forms of set two of initiating work are:

SET 2.

1. Card catalogue of clients.
2. Form for ratifying instructions.....U. T.
3. Form of recording expenses.....U. T.
4. Form of drafting, time sheets.....U. T.
5. Form confirming approval and acceptance of studies.....U. T.
6. Form for approval of clauses of specification, of contract and approval of list of bidders.....U. T.
7. Office order for preparation of drawings or specifications.....U. T.
8. Record of orders of blue prints.....U. T.
9. Form of book-keeping account with clients.....U. T.
10. Form of bill for services.....U. T.
11. Card catalogue, receipts for things sent out (for comment or for work).....U. T.
12. Posting book of things issued and things received.....U. T.

Note.—"U. T." indicates that after a form has been called into use it is then "Used Throughout" in the following steps.

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The common forms of set three of carrying work to the stage of awarding a contract are:

SET. 3.

1. General conditions for specifications.
2. Forms of specification (sheet size, binding, arrangement of contents).
3. Card catalogue of bidders (indexed by trades).
4. Postal form inviting a call for estimating.
5. Proposal.
6. Estimates record sheets.
7. Acceptance of proposal.
8. Postal notification of award of contract.
9. Card catalogue of work under contract (indexed by name of project).
10. Schedule of unit prices.
11. Contract.
12. Bond.
13. Labels for models and samples.

The common forms of set four of having work conducted and concluded are:

SET 4.

1. Superintendent's daily report.
2. Shop work inspection reports.
3. Reports of tests of materials.
4. Ledger account with contractor, or a contract account folding cover
5. Blanks for contractors to make statement of changes.
6. Order of extras.
7. Order for omissions.
8. Order for special work not measured by unit prices.
9. Changes record sheet.
10. Requisition or application for payment.
11. Certificate of payment.
12. Voucher of payment.
13. Contractor's affidavit of amounts he owes subs.
14. Subcontractor's affidavit of amount contractor owes him.
15. Waiver of lien.
16. Notice of discharge of bond.

Such is a fairly complete list of common forms, samples of many of which I have here for your inspection.

Unity in size for a set of forms would offer no disadvantage in serviceability for use and would afford the maximum of uniformity for filing. Such however has not yet been deemed practicable, and so we attain as nearly as may be to perfect utility for sets of forms by adopting sizes for the various sheets which are

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multiples of a fixed unit. That unit in many offices is the size of a letter-head of $8\frac{1}{2} \times 11$ to 8×10.

When having to devise forms, start out with the idea that the dominant characteristics of a model form should be: Convenience in size, individuality in color, usefulness in subject matter. Consider too, that it is sometimes expedient to restrict size, or to separate matter by using both sides of the form rather than only the face.

Bear in mind that color, as well as size, should be used to emphasize individuality for facilitating ready identification.

Now a few words about the drawings: Drawings are more convenient if kept flat rather than rolled either for current work or for finished work.

For facilitating drafting room work, a copy of each drawing of current work should hang on a rack in the drafting room and is most serviceably a cloth-mounted white print, having two opposite edges bound between oak slats by McGill fasteners. A uniform size of sheet using a multiple for details should be adopted for all the drawings of each building. It has been found that relatively few full-sized details require a sheet larger than 27×40.

Drawings of finished work are most compactly kept by enclosing those of each building in very large envelopes, labelled by tags with the building number and laid flat on shelves in the order of numbering.

A card catalogue drawer of drawings of current work indexed by the character of the building, which may be further emphasized by the color of the cards as white for public buildings, red for ecclesiastical buildings, yellow for domestic buildings, giving the number of the building with one card back of a guide card for each ten drawings, five on a side of a building, on which is entered the building number, the drawing number, title, date of making, date of revising, name of author serves for a record of drawings.

Each guide card has on it "Location," "Owner," "Description," "Total Cost," "Cube Contents," "Cost per cu. ft.," "Date of first contract," "Date of final payment."

In the front of the drawer should be key cards to draftsmen's initials, and key cards of the number of each piece of current work.

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A common scheme for classifying drawings using a numbering system is to designate preliminary drawings, sketches and studies by letters of the alphabet as A. 1, meaning drawing no. 1 of first set of sketches; B. 1, meaning drawing no. 1 of second set of sketches, etc. Then to set apart nos. 1 to 99 for numbering general drawings, plans, elevations and sections.

100 to 199 for numbering constructional steel and ornamental iron drawings.

200 to 299 for numbering plumbing, sewerage, electrical and heating drawings.

300 to 399 for numbering scale details, interiors, etc.

400 to 499 for numbering (on buff-colored cards) full-sized details.

500 to 599 for numbering (on blue-colored cards) shop drawings.

This can be elaborated by using subdivision markings to indicate the trades work shown (as A to D for granite, E to I for terra cotta, etc.), and also by doubling the alphabet letters for indicating the kind of drawing (as AA for extra prints, BB for framing prints, CC for cloth tracings, DD superseded, etc.), and when so used such is a most convenient system for ready identification.

Each drawing should be labelled with a date, its building number, its class number, name of the building, name of the drawing, scale, the initials of its maker, the initials of the one who traced it, the initials of the one who checked it and the initials of the one authorizing its issue. It is of course also lettered with other titles and names, etc., as one chooses.

In figuring dimensions on drawings, the chances of error are diminished by running all interior lines through to full totals and by running complete lines in pairs particularly on each of the four sides of the plans, fixing every dimension of each feature by more than one measurement.

Each room should be designated on the plans by a name, or a number and each door and window opening should have a number on the plans. For this latter, it is usual to set apart numbers 1 to 99 for the openings of the lowest story; numbers 100 to 199 for the openings of the next story above the lowest and so on.

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The subject of contracts, I believe your courses include instruction in, so I will not go into it other than to say it is found best to have contracts executed in triplicate so as to provide a copy for each interested party. Attach to the office copy a schedule of unit prices, a copy of the proposal, a copy of the bond and a memorandum showing how the contract sum was determined.

Have the contractor sign a set of blue prints of the drawings and sign the specifications. Notations of changes with date, arising after signing a contract, should be made in ink on a set of drawings kept with the contract set and should not be made on the contract set.

A contract does not commonly, but should always state dates for the completion of various stages of the work in order to establish a firm basis in the case of default on which to rest an order of cancellation.

There is at present a judgment forming that a building contract should be reduced in matter to a bare agreement—to build —by a certain time—completing portions of the work at certain dates—for a certain price—to be paid at certain intervals—and to relegate all other modifying provisions to place in the general conditions of the specification. I have not as yet had time to study the legal aspect of such a step; it has its advantages in conducing to system and to simplicity.

The filing of photographs, magazine plates, clippings, etc., is most successfully done in units of vertical cabinet files of four drawers high, each drawer 10 × 14 in size.

The material is separated into groups of multiples of ten by the folders they lie in, or by heavy cardboard index cards of the groups.

Photographs need no folders, but are numbered on the margin.

A card catalogue drawer for indexing the contents of filing cases enables one to introduce cross reference and minute classification of the photographs, plates, etc., for the application of which I refer you to the two following interesting publications: Bulletin number 9, University of Illinois; Urbana, Ill., called "An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industries"; Bulletin number 13, University of Illinois, Urbana, Ill., "An Extension of the Dewey Decimal System of Classification Applied to Architecture and Building."

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The filing of catalogues for convenient reference can be accomplished in exactly the same way as described above for filing photographs.

My talk has now substantially informed you of the elements and of their importance on the business side of practice; such is as much as can be done at this time.

I have here a few models which you may look over, some of which have been collected by the Committee on Employment and on Office Practice of the Society of Columbia University Architects, who give special attention to this matter and through whose courtesy I am able to show such forms to you.

On closing, I wish to recommend that you adopt a comprehensive scheme of forms and systems at the beginning of practice. It need not be elaborate for your early usefulness, but it can be expanded as your practice grows. By so doing, you will escape the plagues of adopting early devices to later complicated conditions. I would emphasize again that you bear in mind in devising forms that uniformity in size, variation in color and simplicity of application are the distinguishing marks of a model set which you will then find will operate themselves.

Finally make it a habit: To write down everything and keep what you write in appropriate files; to confirm every verbal understanding; to date all drawings, documents and memoranda; to give every piece of work a number and make it the filing number for all letters, drawings, specifications and records of such piece of work.

I thank you for your attention.

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(Contribution from the Havemeyer Laboratories of Columbia University, No. 172.)

A STUDY OF THE EFFECT OF EXCESS OF REAGENT AND TIME OF REACTION IN THE DETERMINATION OF IODINE NUMBERS OF FATTY OILS.

By DWIGHT A. BARTLETT and H. C. SHERMAN.

It is well known that the numbers expressing the halogen absorption of fatty oils, while commonly referred to as "analytical constants," do in fact vary not only as between different samples of the same species, but also with such analytical conditions as the nature of the halogen reagent employed, the amount present in excess of that absorbed, and the time during which it is allowed to act upon the sample.

Since Hübl's original publication* in 1884, the determination of the iodine number has been the most generally useful of the chemical methods employed in fatty oil analysis, yet there is still much difference of opinion as to the conditions under which the iodine number should be determined.

It is true that by the use of the iodine chloride solution of Wijs† or of the iodine bromide of Hanus‡ the variations which result from small changes in conditions become somewhat less than with the Hübl method, but the latter is still the authorized method of the United States Pharmacopœia, and is given first place among the official methods used in food inspection work in the United States§ and while it is probable that the newer methods will gradually replace the method of Hübl it will still be important to know under what conditions the Hübl reagent gives correct results in order that the great mass of data which has been accumulated by the use of this reagent may be properly interpreted and correlated with the results obtained by the newer methods. Accordingly in undertaking a study of some of the conditions affecting the iodine numbers of fatty oils we have considered first the Hübl method.

* Dingler's *Polyt. Journ.*, 1884, 253, 281.

† *Ber. deut. chem. Ges.*, 1898, 31, 750.

‡ *Ztschr. Unters. Nahr. Genussm.*, 1901, 4, 913.

§ U. S. Dept. Agriculture, Bur. Chem. Bul. 107 (Rev.), p. 136.

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In his original directions, Hübl provided simply a sufficient excess of reagent to show after two hours contact with the sample a distinct coloration due to free iodine. Under such conditions he believed that the addition of halogen would be complete in two hours and that longer standing would not materially influence the results.

Archbutt,* in 1886, undertook to determine the influence of excess of reagent and time of its action upon the amount of iodine absorbed by rapeseed oil. Two grams of pure rapeseed oil were dissolved in chloroform mixed with 150 c.c. of Hübl solution, the whole diluted to 250 c.c. and allowed to stand, 25 c.c.-portions of the solution being withdrawn at intervals and titrated with the following results.

Time of Standing.	Iodine Number.
1½ hours	98.3
3¼ hours	99.8
5¼ hours	100.4
24 hours	100.6
53 hours	99.7

In another experiment 2 grams of the oil were dissolved in chloroform and diluted to 100 c.c. Five 10 c.c.-portions of this solution were transferred to separate flasks, mixed with increasing quantities of Hübl reagent, allowed to stand three and one-fourth hours and titrated with the following results:

Number of Test.	Iodine (in Terms of Thiosulphate Solution).		Iodine Number.
	Absorbed.	Unabsorbed.	
	c.c.	c.c.	
I.	15.37	3.57	97.3
II.	15.67	7.08	99.2
III.	15.67	10.90	99.2
IV.	15.83	14.52	100.2
V.	15.93	18.18	100.8

As the result of his experiments Archbutt recommended that sufficient reagent be used so that the amount remaining free should at least aqual the amount absorbed, and that the reagent be allowed to act for six hours.

Thompson and Ballantyne† found that seal oil and linseed oil

* *Journ. Soc. Chem. Ind.*, 1886, 5, 308.

† *Journ. Soc. Chem. Ind.*, 1890, 9, 588.

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when treated with at least double the amount of iodine which they were capable of absorbing required eight hours for a maximum result.

Holder* recommended the use of Hübl solution not over eight days old in sufficient amount to furnish three to four times as much iodine as the oil can absorb, so that 70 to 75 per cent. of the iodine offered remains unabsorbed. Under these conditions he found that two hours sufficed even for linseed oil.

In the series of experiments in which the time was always two hours and the amount of Hübl solution was varied, Holde obtained the following results:

Kind of Oil.	Hübl Solution.	Iodine Remaining Unabsorbed.	Iodine Number.
	c.c.	c.c.	
Linseed oil — weak Hübl solution.	30	50	158.8
	40	58	164.8
	50	65	169.4
	60	70	172.1
	70	76	173.0
	80	78	173.1
Linseed oil — fresh Hübl solution.	30	58	167.2
	40	66	171.2
	60	78	175.1
	70	81	175.1
	80	83	174.4
Walnut oil — fresh Hübl solution.	20	50	136.5
	25	60	135.3
	40	74	136.2
Rape oil.	17	44	97.6
	20	57	98.8
	35	78	99.7
	45	82	100.3
	55	84	100.3

Dieterich† found that when the Hübl solution was allowed to act upon the oil for twenty-four hours the results were too high if the blank was titrated at the beginning because the reagent on long standing with the sample lost iodine by deterioration in addition to that which the oil absorbed, while if the blank was titrated at the end of the twenty-four-hour stand the results were too low because the blank with its greater amount of iodine deteriorated more rapidly. In order to avoid these discrepancies it was suggested that the loss of strength of the blank be determined and an

Chem. Ztg., 1892, 16, 1176.

†*Analyst*, 1892, 17, 219.

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allowance be made for a proportionate deterioration in the iodine found unabsorbed in each determination.

Fahrion* considered that so large an excess of iodine as Holde had recommended was not only unnecessary, but detrimental through increasing the probable loss of iodine by deterioration of the excess of reagent.

Ulzer† states that reliable results are obtained both with Hübl's and with Waller's reagent, if the excess of iodine solution be maintained at double the quantity of iodine absorbed, and that six hours will then suffice for the reaction. Ulzer directs that the iodine solution be prepared forty-eight hours before use and says that it may be employed so long as 25 c.c. consumes at least 35 c.c. of tenth-normal thiosulphate solution.

Wijs‡ repeated Holde's warning against the use of old Hübl solution, especially when working with linseed oil, and stated that a solution five days old required twenty-four hours to give as complete an absorption with linseed oil as could be obtained in seven hours with a fresh solution. In proposing his reagent of iodine mono-chloride in glacial acetic acid, Wijs recommended that it be used in such quantity that only about 30 per cent. of the halogen would be absorbed and that the excess be titrated at the end of fifteen to sixty minutes in contact with the oil. Harvey,§ however, claims that such a large excess of the Wijs reagent is not necessary. Tolman|| also considers that the excess of Wijs solution need not be large, as he found practically the same results with linseed oil treated thirty minutes with Wijs solution whether the reagent was used in such quantity as to leave two thirds, one half or only one third of the halogen unabsorbed.

Richter¶ found that when Wijs solution was allowed to act for two hours upon olive, rapeseed or sunflower seed oil, the results were essentially uniform whether two and one half, three or four times as much halogen was offered as was absorbed.

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* *Chem. Ztg.*, 1893, 17, 1100.

† *Journ. Soc. Chem. Ind.*, 1898, 17, 276.

‡ *Ber. deut. chem. Ges.*, 1898, 31, 750.

§ *Journ. Soc. Chem. Ind.*, 1902, 21, 1437.

|| *Journ. Amer. Chem. Soc.*, 1904, 26, 826.

¶ *Ztschr. angew. Chem.*, 1907, 1606.

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Experiments with Hübl Solution.

Experiments have been made with olive, corn and linseed oils taken as typical of the non-drying, semi-drying and drying oils respectively. The Hübl solution was prepared by dissolving 26 grams of iodine and 30 grams of mercuric chloride in 475 c.c. of Kahlbaum's 99.8 per cent. alcohol and diluting with water to 500 c.c. and was used while strictly fresh. The manipulation was conducted as directed in Sherman's "Methods of Organic Analysis," pp. 131–135, except for the variations in the amount of iodine solution added and the time of standing. In all cases the blanks were prepared at the time the iodine was added to the samples and stood as long as the samples, the iodine in the blank being titrated at the same time with the unabsorbed iodine of the sample. In order to facilitate the application of our results in the analysis of oils whose iodine numbers are entirely unknown we always added (irrespective of the iodine number of the oil with which we were working) either 1, 1.5 or 2 c.c. of Hübl solution to each centigram (0.01 gram) of sample taken.

The determinations were made in sets of eight flasks each; no. 1, blank containing 50 c.c. of Hübl solution; nos. 2 and 3, each 1 c.c. Hübl solution per 0.01 gram oil; nos. 4 and 5, each 1.5 c.c. Hübl solution per 0.01 gram oil; nos. 6 and 7, each 2 c.c. Hübl solution per 0.01 gram oil; no. 8, blank containing 25 c.c. Hübl solution. By the use of two blanks in each set one containing 50 c.c. and the other only 25 c.c. of the iodine solution and by the use of high quality alcohol as a solvent, it was hoped to minimize the error due to deterioration of the iodine solution during the time of standing.

The following table gives the average iodine number found for each oil under each of the conditions studied.

In the case of either olive oil or corn oil, three hours' standing with 1.5 or 2 c.c. of Hübl solution per centigram of sample or four hours' standing with 1 c.c. per centigram is evidently ample. With 1 c.c. per centigram the results are not influenced by extending the time to five or six hours. With 1.5 or 2 c.c. per centigram the results are practically uniform whether the time be three, four, five or six hours. When allowed to stand eighteen to twenty-five

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INFLUENCE OF EXCESS OF REAGENT AND TIME OF STANDING UPON HÜBL NUMBER.

Kind of Oil and Time of Standing.	Amount of Reagent per Centigram of Sample.	Proportion of Iodine Remaining Unabsorbed, About.	Iodine Number Found.
Olive oil (3537)	c.c.	Per Cent.	Average.
3 hours.	1	65–70	80.5
3 "	1.5	75–80	81.3
3 "	2	80–85	81.4
4 "	1	65–70	81.6
4 "	1.5	75–80	81.9
4 "	2	80–85	81.7
5 "	1	65–70	81.2
5 "	1.5	75–80	81.7
5 "	2	80–85	81.4
6 "	1	65–70	81.4
6 "	1.5	75–80	81.4
6 "	2	80–85	81.4
18 "	1	65–70	81.4
18 "	1.5	75–80	79.9
18 "	2	80–85	78.8
20 "	1	65–70	79.3
20 "	1.5	75–80	78.0
20 "	2	80–85	78.0
22 "	1	65–70	77.9
22 "	1.5	75–80	78.5
22 "	2	80–85	79.0
25 "	1	65–70	81.7
25 "	1.5	75–80	80.3
25 "	2	80–85	83.4
Corn oil (2056)			
3 hours.	1	45–50	121.2
3 "	1.5	60–65	121.7
3 "	2	75–80	121.6
4 "	1	45–50	121.9
4 "	1.5	60–65	121.7
4 "	2	75–80	121.8
5 "	1	45–50	121.5
5 "	1.5	60–65	121.3
5 "	2	75–80	121.3
18 "	1	45–50	119.7
18 "	1.5	60–65	120.9
18 "	2	75–80	119.4
Linseed oil (2052)			
3 hours.	1	30–35	164.7
3 "	1.5	50–55	169.8
3 "	2	70–75	172.3
4 "	1	30–35	167.0
4 "	1.5	50–55	171.2
4 "	2	70–75	171.9
5 "	1	30–35	170.2
5 "	1.5	50–55	170.6
5 "	2	70–75	172.4
18 "	1	30–35	172.9
18 "	1.5	50–55	172.9
18 "	2	70–75	172.2

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hours the results tended to become irregular whether 1, 1.5 or 2 c.c. of Hübl solution per centigram of oil were used.

In the case of linseed oil 1 c.c. of Hübl solution per centigram of oil is insufficient (even though the reagent is used within twelve to eighteen hours after mixing) unless the reaction be allowed to continue over-night. A similar long standing appears to be required when 1.5 c.c. of Hübl solution per centigram of linseed oil is used, but by using 2 c.c. per centigram the reaction appears to be practically complete in three hours.

This, however, will not be the case unless the Hübl solution is absolutely freshly prepared as the following results will show.

Experiments with Old Hübl Solution.

With linseed oil the age of the Hübl solution was found to exert a very decided influence. In the following table are shown the iodine numbers found with new and old Hübl solutions when all other conditions were the same.

Influence of Age of Hübl Solution.

Linseed Oil (2.052) Time of Action.	Reagent per Centigram.	With New Hübl.		With Old Hübl.	
		Age of Reagent.	Iodine Number.	Age of Reagent.	Iodine Number.
	c.c.				
3 hours.	1	16 hours.	164.7	3 days.	163.5
3 "	1.5	16 "	169.8	3 "	165.0
3 "	2	16 "	172.3	3 "	166.9
4 "	1	16 "	167.0	1 week.	161.5
4 "	1.5	16 "	171.2	1 "	164.0
4 "	2	16 "	171.9	1 "	165.4
5 "	1	16 "	170.2	4 days.	165.3
5 "	1.5	16 "	170.6	4 "	170.5
5 "	2	16 "	172.4	4 "	167.4
18 "	1	16 "	172.9	3 "	172.8
18 "	2	16 "	172.6	3 "	172.9

From these results it appears that Hübl solution three or four days old even though made up with exceptionally good quality alcohol, is distinctly slower in its action upon linseed oil than a solution which has been prepared the previous evening. The differences in results obtained by the new and old solutions were, however, practically eliminated when both were allowed to act upon the oil during eighteen hours.

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Experiments with Wijs Solution.

This solution was made by dissolving weighed amounts of iodine and iodine trichloride in glacial acetic acid so as to obtain a solution of iodine monochloride with nearly the same halogen strength as the Hübl solution.

Influence of Excess of Reagent and Time of Standing upon Wijs Numbers.

Kind of Oil and Time of Standing.	Amount of Reagent per Centigram Oil.	Proportion of Halogen Remaining Unabsorbed (About).	Iodine Number.
	c.c.	Per Cent.	Average.
Linseed oil.			
30 minutes.	1	29.	181.4
30 "	1.5	52.	185.8
30 "	2	64.	191.0
1 hour.	1	29.	184.4
1 "	1.5	52.	186.8
1 "	2	64.	189.4
2 hours.	1	29.	186.5
2 "	1.5	52.	187.8
2 "	2	64.	190.3

Here the results are notably higher throughout than those obtained by means of the Hübl reagent. One or 1.5 c.c. of Wijs solution per centigram of linseed oil was insufficient for a maximum addition even when allowed to act for two hours. Two c.c. of Wijs solution per centigram of oil gave a maximum result in thirty minutes.

When time permits we hope to study the Wijs and Hanus methods in greater detail but the results so far obtained appear to justify the following conclusions.

Conclusions.

1. In both the Hübl and Wijs methods the use of a liberal excess or reagent greatly shortens the time required for a complete reaction.

2. In the Hübl method it is preferable to use a large excess of reagent for three to four hours rather than a smaller excess for eighteen hours, because on long standing the results tend to become irregular, probably through deterioration of the iodine solution remaining in excess.

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3. In the case of linseed oil a freshly mixed Hübl solution (less than twenty-four hours old) should be used, as with solutions even three days old the reaction is much retarded and requires long standing for completion.

4. In the examination of fatty oils of unknown capacity for halogen absorption it is recommended that 2 c.c. of fresh Hübl solution, or of Wijs solution of equivalent strength, be used for each centigram of sample and that three hours be allowed for the reaction in the case of the Hübl, or thirty minutes in the case of the Wijs reagent.

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(Contributions from the Havemeyer Laboratories of Columbia University, No. 173.)

A COMPARISON OF THE CALCULATED AND DETERMINED VALUES FOR THE SPECIFIC TEMPERATURE REACTIONS OF OIL MIXTURES WITH SULPHURIC ACID.

By W. H. BOYNTON and H. C. SHERMAN.

In a paper* published from this laboratory in 1902 it was shown that the practice of diluting fatty oils with equal amounts of mineral oil in order to moderate the reaction with concentrated sulphuric acid introduces an error if the rise of temperature of the mixture be taken as the mean between the results which would be obtained from the mineral oil and the fatty oil separately. In other words, the temperature reaction of such oil mixtures with sulphuric acid is not an additive property as had been assumed up to that time. Similar results were afterward published by Suzzi† who, however, found no such discrepancy on mixing two fatty oils.

Richter‡ has recently published experiments in which the addition of 5 to 10 per cent. of sunflower, rape or peanut oil depressed the specific temperature reaction of olive oil, and other mixtures of olive and rape or olive and peanut oils gave results constantly lower than the calculated values while with mixtures of olive and sunflower oils containing 20 per cent. or more of the latter the results found were sometimes above and sometimes below the calculated values, the differences being never greater than 5 units.

Moreover, we have recently§ shown that the viscosity numbers and flashing and burning points of oil mixtures are not additive properties, the values found for mixtures of heavy and light petroleum lubricating oils and of petroleum with sperm oil and fatty oils being always below the calculated values. We have therefore

* *Journ. Amer. Chem. Soc.*, 24, 266.

† *Abs. J. Chem. Soc.*, 88, ii., 619.

‡ *Ztschr. angew. chem.*, 1907, 1605.

§ *Journ. Ind. Eng. Chem.*, 1, 13 (1909).

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been led to return to our experiments upon the specific temperature reactions of oil mixtures with a view to determining the extent of the differences between the calculated and observed values in some typical mixtures of fatty oils with mineral oils and with each other. The specific temperature reaction we have determined as previously described by one of us.* The acid used gave with water a rise of temperature of 44° C.

All of the determinations upon the original oils and most of those upon the mixtures were made at least in triplicate, the average results only being given in this paper.

The results obtained upon testing the oils individually averaged as follows:

Kind of Oil.	Specific Temperature Reaction
Paraffine oil	0.5
Mineral oil	18.0
Neatsfoot oil	80.4
Olive oil	95.35
Lard oil	132.75
"Sperm" oil	150.5
Cottonseed oil	193.9

The sample of sperm oil proved to be impure, the other samples were obtained from reliable sources and appeared to be of fair commercial grade although the lard oil gives an exceptionally high value.

In the following table are given the calculated and observed values for 33 mixtures including 11 different combinations each in the three proportions (3:1; 2:2; 1:3) together with a statement of the extent to which the observed results exceed the calculated values.

* "Methods of Organic Analysis," pp. 135–138.

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SPECIFIC TEMPERATURE REACTIONS OF OIL MIXTURES.

Oil Mixture.	Specific Temperature Reaction.		
	Calc.	Found.	Found in Excess of Calc.
Paraffin oil ¾ ; neatsfoot oil ¼	20.4	46.1	25.7
" " ½ ; " " ½	40.4	63.6	23 2
" " ¼ ; " " ¾	60.4	72.2	11.8
" " ¾ ; olive " ¼	24.2	50.0	25 8
" " ½ ; " " ½	47.9	70.5	22.6
" " ¼ ; " " ¾	71.5	83 0	11.5
" " ¾ ; lard " ¼	33.5	61.7	28.2
" " ½ ; " " ½	66.6	90.0	23.4
" " ¼ ; " " ¾	99.7	113.75	14.0
" " ¾ ; cottonseed oil ¼	48.8	74.8	26.0
" " ½ ; " " ½	97.3	121.0	23.7
" " ¼ ; " " ¾	145.7	157.4	11 7
Mineral oil ¾ ; neatsfoot oil ¼	33.6	53.7	20.1
" " ½ ; " " ½	49.2	68.2	19.0
" " ¼ ; " " ¾	64 8	74.4	9.6
" " ¾ ; lard " ¼	46.7	73.1	26.4
" " ½ ; " " ½	75.4	97.5	22.1
" " ¼ ; " " ¾	104.1	115.1	11.0
" " ¾ ; sperm " ¼	51 1	75.0	23.9
" " ½ ; " " ½	84.2	107.8	23 6
" " ¼ ; " " ¾	117.4	129.3	11.9
" " ¾ ; cottonseed oil ¼	62 0	85.2	23.2
" " ½ ; " " ½	106.0	128.5	22.5
" " ¼ ; " " ¾	150.0	159.5	9.5
Neatsfoot oil ¾ ; cottonseed oil ¼	108.8	102 1	—6 7
" " ½ ; " " ½	137.2	127.8	—9.4
" " ¼ ; " " ¾	165.6	159.8	—5.8
Olive " ¾ ; " " ¼	119.9	117.5	—2.4
" " ½ ; " " ½	144.6	143.0	—1.6
" " ¼ ; " " ¾	169.3	167.9	—1.4
Lard " ¾ ; " " ¼	148.7	147.6	—1.1
" " ½ ; " " ½	163.8	161.6	—2.2
" " ¼ ; " " ¾	178.9	177.4	—1.5

It will be seen that the specific temperature reaction found in a mixture of two fatty oils did not as a rule differ materially from that calculated, and when different was below the theoretical value; while in mixtures of fatty and mineral oils the figures found were invariably higher than those calculated.

The differences between the calculated and the observed figures in the mixtures of fatty and mineral oils containing 25 to 75 per cent. of the latter increased with the percentage of mineral oil in the mixture, and appear to have been governed by the proportion of mineral oil rather than by the nature of the fatty oil present.

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ABSTRACTS—ANALYTICAL CHEMISTRY.

By E. Waller.

Ammonium Nitrate in the Analysis of Metals. Loviton (*Ann. Chim. analyt.*, XIV., 325). Fused NH_4NO_3 attacks certain metals, such as Cu, Zn and Ni. Fe, Sn, Sb are not at all or but slightly attacked. With certain alloys, the reagent may be used in this way to effect a separation. 2 to 4 gms. of the alloy are heated with fused NH_4NO_3 until perceptible action has completely ceased, then cool, and extract with water. For the determination of iron in copper, brass and nickel, the method has been found expeditious and accurate.

Alkalinity of Bleach Solutions. Jones (*Analyst*, XXXIV., 317). Add a known amount of N/10 HCl (excess) and pass a rapid current of air for 45 minutes or until free from Cl, protecting the solution meantime from the light. When the solution will no longer bleach a drop of methyl orange, add that indicator, and titrate back with N/10 NaOH. Allowance must be made for the acid neutralized by the hypochlorite present.

Free Acid in Copper Electro-deposition Baths. de Debaisieux (*Bull. Soc. Chim. Belge*, XXIII., 310). Sims has proposed diluting a known volume of the solution until 100 c.c. contains 3 gms. $CuSO_4$, then adding 4 drops methyl orange, and titrating with standard $NaHCO_3$ until a green tint is obtained. The author finds that this method gives correct results.

Potassium-Flame Test. Moir (*J. Chem. Met. & Min. Soc. So. Africa*, IX., 292). At the meeting of March 20, 1909, Dr. Moir exhibited glasses made by covering the surface with gelatine films stained with different dye stuffs, for use in viewing colored flames. One which practically transmitted only the rays from the potassium flame, was made with two films, one stained deeply with methylene blue, the other with methyl orange. The suggestion is made that by means of suitably dyed films means for the detection of numerous elements by the flame test might be obtained.

Free Lime in Cement. Brandenburg (*Chem. Ztg.*, XXXIII., 880). Add NH_4Br dissolved in absolute alcohol, and distil. The NH_3 coming over constitutes the measure of the free CaO. The absolute alcohol requires careful dehydration by distilling repeatedly over CaO and kept standing over "activated" Al. In such alcohol the NH_4Br is not decomposed by boiling either alone or in presence of $CaCO_3$.

Lime in Basic Slag. Hendrick (*J. S. C. I.*, XXVIII., 775). The amount of free lime in basic slag has importance in connection with its use as a fertilizer. From various statements in the literature, it seems to be accepted by some that the average free lime is about 15 per cent. Recorded determinations vary from 2 to 21 per cent. The author tried

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the method by extraction with a 10 per cent. sugar solution, the mixture being vigorously agitated for 4 hours, and the alkalinity being determined on an aliquot portion. The results by this method showed from under 1 to at most 3 per cent. in a series of samples. The method frequently used — agitation with a 1 per cent. solution of NH_4Cl, settling, and determining alkalinity of the extract, was found to give higher results invariably. Shaking up with boiled and cooled distilled water gave lower results than by the sugar method, but the longer the shaking was continued the nearer did the results approach those with sugar solution. Experiments indicated that some of the CaO was loosely combined (to some extent as tetracalcium phosphate — $Ca_3P_2O_8.CaO$) and in other combinations.

Lime in Cement, Mortars, etc. Rapid method. Balthasar (*Chem. Ztg.*, XXXIII., 646). A special mixture is used in this process, containing 25 gms. NH_4Cl, 100 c.c. glacial acetic, and dilution to 1 litre with strong NH_4OH.

0.7 gm. of the material is dissolved in conc. HCl. The solution is rinsed into a 350 c.c. flask making a volume of 50 to 100 c.c., boiled a few minutes to expel CO_2, then 50 c.c. of the special mixture is added, and the mixture brought to boiling. 50 c.c. of N/2 oxalic acid are then added, and the flask is cooled. It is then diluted to the mark, well stirred for about three minutes and poured on a dry filter. The first few c.c. of the filtrate are usually to be rejected, because turbid. 50 c.c. of the clear filtrate are titrated with N/10 permanganate after addition of about 5 c.c. conc. H_2SO_4 and a little $MnSO_4$.

Aluminium, Chromium and Iron. Schirm (*Chem. Ztg.*, XXXIII., 877). The filtration and washing of a precipitate of $Al_2(OH)_6$, $Cr_2(OH)_6$ and $Fe_2(OH)_6$ produced by NH_4OH, is troublesome, and never altogether satisfactory. The author finds that a denser, and more easily managed precipitate is obtained by use of NH_4NO_3 together with NH_4OH in a boiling solution. The solution should contain 0.1 to 0.2 gm. of the metals, and is neutralized with NH_4OH as closely as possible without producing a permanent precipitate. It is then diluted to 250 c.c. Then 20 c.c. of a 6 per cent. solution of NH_4NO_3 is added, and it is boiled until the odor of nitrogen oxides has disappeared. Then allow to stand 20 or 30 minutes on the water bath when it may be filtered, washing at first by decantation.

If the solution originally contained too much NH_4 salt, the supernatant liquid will become a little acid by boiling, and the precipitation will be incomplete unless a little more NH_4OH is added.

Ferric Oxide and Alumina in Phosphate Rock. Gladding (*J. Ind. Eng. Chem.*, I., 249). Boil 5 gms. of the sample with HCl for an hour. Oxidize all Fe by boiling with a little H_2O_2, cool and dilute to 250 c.c. Use 50 c.c. of this solution for determining Fe in the ordinary manner — reduction and titration by permanganate, etc. Heat 25 c.c. to boiling and slightly overneutralize with NH_4OH, then add HCl until just clear, and introduce 1 gm. crystallized $(NH_4)_2C_2O_4$, boil gently for some minutes, and filter off CaC_2O_4. Add 5 c.c. H_2SO_4 to the filtrate, and boil down to fumes in a Kjeldahl flask. Dilute up with

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50 c.c. H_2O, add 5 c.c. HCl, boil until clear, then dilute further to 150 c.c., neutralize closely with NH_4OH, add 25 c.c. $NH_4C_2H_3O_2$ solution and boil. Filter and wash with boiling 2.5 per cent. NH_4NO_3 solution. Ignite and weigh $FePO_4$ and $AlPO_4$. The Fe found above is calculated to $FePO_4$ and deducted. The remainder multiplied by 0.418 gives Al_2O_3.

Iron in Ores. Rapid method. Maclaurin and Donovan (*J. S. C. I.*, XXVIII., 827). A weighed amount of the pulverized ore is placed in a hard glass bulb tube by the aid of a small copper scoop constructed for the purpose. Corks carrying small glass tubes are then fitted to the ends of the tube. If the ore contains organic matter heat the bulb to redness for a few minutes while passing through it a current of air. Eventually pass a current of H, and heat to redness in that for 10 to 30 minutes according to the nature of the ore. Then after cooling, the reduced ore is shaken into a flask containing some $NaHCO_3$ and a little water. Rinse the tube finally into the flask with dilute H_2SO_4. Enough acid must be added to dissolve the reduced iron, on boiling for 5 to 20 minutes, suitable precautions being taken (by passing a current of CO_2 or some other device) to prevent re-oxidation of the iron during solution. After solution and cooling, titrate with permanganate.

Chromium in Small Amounts in Iron and Steel. (*Stahl u. Eisen*, XXIX., 249.) Dissolve 5 to 10 gms. in HCl, filter and add Zn to reduce Fe. Then run in a slight excess of an emulsion of ZnO in water; bring to boiling, then stand to settle. Filter off the precipitate which contains Cr besides excess of ZnO, etc. If the ZnO is large redissolve, reduce and reprecipitate. Filter, wash, dry and ignite. Then mix well with 2 parts Na_2CO_3 and 3 parts MgO and heat in an open muffle for about an hour. Cool, leach out chromate with hot water, add KI, acidify with HCl, allow to stand a few minutes, and titrate with standard $Na_2S_2O_3$.

Nickel and Cobalt Detection. Grossmann and Heilborn (*Ber.*, XLI., 1878). The solution should be concentrated, and should not contain an excess of acid: Add NH_4OH; then a solution of cane sugar; then dicyandiamide sulfate; now on adding NaOH, Ni if present gives a yellow or yellow-red precipitate while Co causes an intense red or violet coloration in the liquid.

Nickel and Cobalt Separation. Pritze (*Chem. Ztg.*, XXXIII., 694). The separation depends on the solubility of cobalt ammonium thiocyanate in a mixture of amyl alcohol and ether, the corresponding Ni compound being insoluble except to a very slight extent. If the Ni largely predominates, say 100 times that of the Co, some Ni may still remain with the Co, at the first treatment. This may be separated by a second treatment or preferably by use of dimethyl glyoxime.

Zinc, Copper or Cobalt. Precipitation by ammonia. Vaubel (*Zts. angew. Chem.*, XXII., 1716). If the solution is first neutralized with fixed alkali or its carbonate (NaOH or Na_2CO_3) and only a very slight excess of NH_4OH added the precipitation on boiling is complete. In

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the case of Cu the addition of NH_4OH must be stopped just when the deep blue color of cuprammonium salts appears, with the others the addition is best controlled by addition of an alkalimetric indicator.

Metal Surface Coatings. Merl (*Pharm. Centrh.*, L., 455). To determine whether an iron surface (kneading troughs, etc.) has been galvanized, apply a few drops of ammoniacal Ag solution. Iron or tinned surfaces are not affected, (Zn) "galvanized" surfaces show black. To distinguish between tinned and terne plate (0.5 per cent. Pb or more) heat about 0.5 gm. of the scrapings in a hard glass (Jena) test-tube with I until it fuses. Cool, add about 10 c.c. of water and boil out excess of I. Filter hot, and note whether on cooling PbI_2 crystallizes out.

Lead in Tin Plate. Knöpfle (*Zts. Unt. Nahr. Genussm.*, XVII., 670). When much Fe is present, the ordinary method of treating with HNO_3 and filtering off metastannic acid gives incorrect results. The $Fe_2(NO_3)_6$ dissolves some Sn which is precipitated with $PbSO_4$ in the subsequent treatment. The method recommended consists in separating the Sn as phosphate. Treat a weighed amount of the materal in a porcelain dish, adding 1 c.c. conc. HNO_3 for each 0.1 gm. of material. Then add water drop by drop until red vapors are no longer evolved. Evaporate until only a moist residue remains. Enough HNO_3 must be kept present to hold Fe in solution. Then add an excess of hot solution of Na_2HPO_4, stirring constantly, and finally 50 c.c. of water. Filter off the stannic phosphate, and determine Pb in the filtrate.

Separation of Lead from Bismuth. Galletly and Henderson (*Analyst*, XXXIV., 389). Bi can be quantitatively precipitated for estimation as phosphate, but efforts to effect a separation from Pb by use of phosphates were failures. The method of Clark (*J. S. C. I.*, XIX., 26) was finally found to be satisfactory. A solution of the chlorides of the two metals was boiled with 1 to 2 gms. of steel wire until the most of the Fe was dissolved. Then the remaining Fe together with the metallic Bi were filtered off and washed, the Pb remaining entirely in the solution and washings.

Antimony in Alloys. Nicolardot and Krell (7th Int. Congress of App. Chem.). The Sb oxides obtained by the treatment with HNO_3 are rendered completely insoluble in HNO_3 by heating to 125°–150°.

Antimony in Thioantimonates. Schulte (*Metallurgie*, VI., 214). If the solution contains no other metals of that group, Mg powder will precipitate Sb completely in a form suitable for weighing and determination. Description is given of the treatment of a plate of Britannia metal by electrotysis, the metal forming the anode, and an iron plate being used as cathode. Na_3SbS_3 solution formed the electrolyte and a considerable excess of NaOH was added to prevent Sn from precipitating a brittle plate containing 99.66 per cent. Sb was thus obtained.

Mercury in Nitro-Explosives. Mann (Report of Dept. of Mines, West Australia, 1907, p. 225). 200 gms. of the explosive were ground up with 400 gms. French chalk, and 250 c.c. water added. After standing 24 hours the solution was filtered, acidified with H_2SO_4 and electrolyzed for 3 to 6 hours, at 1.5 amp. with Au cathode and Pt anode.

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An efficient qualitative method was found to be heating the above mixture of explosive and French chalk for two hours at 70° C. in a corked tube from the cork of which depended a strip of Ag foil. The Hg was afterward indentified by volatilizing with vapor of I in a tube.

Mercury in Solutions Containing Iodide. Wegelius and Kilpi (*Zts. angor. Chem.*, LXI., 413). Direct separation of Hg by H_2S and weighing was found to be erroneous in proportion to the I present. The remedy was found to be warm digestion for about 30 minutes with freshly precipitated (and well washed) AgCl. When the liquid became clear it was filtered, and in the filtrate correct results for Hg as HgS were obtained.

Thorium in Monazite. Hauser and Wirth (*Zts. angew. Chem.*, XXII., 484). When precipitating the cerium earths by $(NH_4)_2C_2O_4$ some Th may dissolve as $Th_2(C_2O_4)_5$. H_2O_2 also does not precipitate it completely. The method given for monazite is: Dissolve 15 to 20 gms. of the finely powdered mineral in conc. H_2SO_4. Heat to expel the excess, and take up with 1 liter of 4.5 per cent. HCl, remove Pb if present, and precipitate cold with excess of $H_2C_2O_4$. Dissolve the oxalate in HNO_3 and precipitate by $Na_2S_2O_3$.

Niobium in Presence of Tantalum. Metzger and Taylor (*Zts. anorg. Chem.*, LXII., 382). The authors have found that succinic acid in the $KHSO_4$ solution of Nb and Ta prevents their separation on dilution or heating, and in such a solution Nb only is reduced by amalgamated Zn, and can be titrated with permanganate. Fuse the mixed oxides with 5 gms. $KHSO_4$, add 10 c.c. conc. H_2SO_4 and heat until a clear solution is obtained; then pour from the crucible into a beaker, rinse the crucible with 30 c.c. H_2SO_4, and let stand until cool. The solution should be perfectly clear. Stir in 2 gms. succinic acid, then add cautiously 20 c.c. of a saturated solution of succinic and eventually 200 c.c. of water. Heat to 75° and pass through a reductor previously warmed by passing through it a warm solution of 5 per cent. H_2SO_4. Rinse through the reductor by warm H_2SO_4 and titrate the brown solution with standard permanganate in an atmosphere of CO_2. The Nb is reduced to an oxide approximating Nb_2O_3. The results differ from those obtained in the fluoride method, but that method is confessedly so imperfect that it cannot therefore be claimed that this method is incorrect.

Vanadium Separation. Jaunasch and Harwood (*J. Pr. Chem.*, LXXX., 127). Vanadium minerals, and alkali metals, vanadates, especially when mixed with four parts of NaCl, when heated in a current of CCl_4 vapor give up all V_2O_5 which can be condensed in dilute HNO_3 in the receiver. Under these conditions P_2O_5 also is carried into the receiver. The V_2O_5 can be reduced and then titrated with permanganate, and subsequently P_2O_5 can be determined in the resulting solution.

Vanadium in Iron and Steel. Auchy (*J. Ind. Eng. Chem.*, I., 455). The V is reduced in the well-known manner by HCl. Then after *twice* evaporating down with H_2SO_4 to remove HCl, the V is titrated *in the cold* by permanganate, without separating Fe. Most of the methods require the previous separation of Fe and titrating *hot*, which is unnecessary, and more liable to error.

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Vanadium in Steels, etc. Jaboulay (*Rev. gen. chim.*, XII., 142). On boiling a solution of ferrous acetate containing V, a precipitate containing all the V is obtained. The fact is utilized thus: Dissolve 5 gms. of the steel in HCl in a 250 c.c. flask. Filter from V carbide, reserving the insoluble material. Add NH_4OH until the precipitate is permanent, then HCl until it clears; then add 10 c.c. glacial acetic and 40 gms. $NaC_2H_3O_2$. Bring to about 350 c.c. and boil for about an hour in an Erlenmeyer flask. Filter through glass wool, and wash with water containing 5 gms. $NH_4C_2H_3O_2$ per liter. Dissolve in HCl, add dilute H_2SO_4 and evaporate to fumes. Meantime fuse up the V carbide and other insoluble material with $KHSO_4$. Dissolve in water and add to the solution from the acetic precipitate. Dilute the combined solutions, nearly neutralize with NH_4OH, cool and titrate. When Cr, W, Mo, etc., are present various modifications may be necessary.

Determining Vanadium and Arsenic when Present Together. Edgar (*Am. J. Sci.*, XXVII., 299). When both are brought to the pentad form, addition of tartaric or oxalic acid reduces V only. This can be titrated by standard I. In another portion treatment with SO_2 reduces both. After expelling excess of SO_2 by boiling and passing CO_2, titration with standard I oxidizes both, the excess of I used over that in the first instance being calculated to As.

Tungsten in Low Grade Wolframite Ores. Hutchin and Touks (*Inst. Min. and Met.*, May 20, 1909). Fusion with alkaline fluxes is replaced by 30 to 45 minutes digestion on a water-bath with 20 c.c. of a 25 per cent. solution of NaOH, adding a little Na_2O_2 to oxidize sulfides, etc. After cooling and dilution to 250 c.c. an aliquot portion is acidified with HNO_3, then made alkaline with NH_4OH, boiled and filtered. In the filtrate the WO_3 is precipitated by $HgNO_3$, the solution being first nearly neutralized and, after adding the reagent, a little HN_4OH, is added. Warming and stirring promote the separation of the precipitate. The method is not applicable to Scheelite.

In some experiments on the analysis of W ores, the authors find that As or F in them increase decidedly the amount of WO_3 held in solution on treatment with aqua regia.

Volumetric for Thallium. Müller (*Chem. Ztg.*, XXX., 297). TlCl was dissolved in a large bulk (200 to 300 c.c.) of water by boiling, cooled to 65° C., acidified with 15 c.c. HCl, and then titrated with standard permanganate. The results were almost uniformly 0.4 per cent. too high. Using a factor differing from the theoretical by 0.4 per cent., they were correct.

On boiling this solution, the $K_2Mn_2O_8$ was destroyed by boiling, and after dilution a known amount of standard $Na_2S_2O_3$ was added (2 to 3 c.c. in excess). Then 25 c.c. of 1 per cent. KI was run in, slowly at first with stirring, eventually starch solution and titration with standard I. The results differed from theoretical by 0.74 per cent. On modifying the factor to this extent, they were found to give uniformly correct results.

Tellurium in Ores. Schelle (7th Int. Congr. App. Chem., London, 1909). The ore is fused with a mixture of Na_2CO_3 and S, or with

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anhydrous $Na_2S_2O_3$, the melt extracted with water, and to the clear solution Na_2SO_3 is added. Metallic Te is thus precipitated. The results are correct in presence of Se, as Sb, Sn, Au or Pb, none of those elements being separated by the Na_2SO_3 under the above conditions.

Halogen Acids in Alkaline Solution. Dehn (*J. Am. Chem. Soc.*, XXXI., 525). In the case of each a mixture as the "hypobromite" (such as is used in urea determinations) N/10 $AgNO_3$ is run in from a burette until the dark Ag_2O begins to show. $NaHCO_3$ is then added until the precipitate becomes white or yellowish, when the precipitate is allowed to settle and then washed by decantation, passing the solution and washings through a Gooch filter. Treat the precipitate in both flask and filter with dilute HNO_3 and titrate the excess of Ag added by standard NH_4CNS. The Br as *bromide* is thus found.

For *hypobromite* is found by adding to another portion some NH_4OH and boiling out the excess, or H_2O_2 may be added to the cold solution. Then add a known amount of N/10 $AgNO_3$ and some $NaHCO_3$, separate the precipitate as before, treat with dilute HNO_3 and determine excess of Ag by standard NH_4CNS.

For *bromate* (or rather for total Br, which presumably is made up of bromide, hypobromite and bromate) reduce the hypobromite as before, then add some finely divided metallic Fe and an excess of H_2SO_4. Filter and treat with known amount of H/10 $AgNO_3$. Boil with HNO_3 to completely oxidize the Fe, and titrate back excess of Ag by NH_4CNS. The procedure is essentially the same in the case of Cl and I but with the latter addition of $NaHCO_3$ is omitted.

Chlorates — Colorimetric. Virgili (*Ann. chim. Appl.*, XIV., 85). The reagents used are: *A*, 50 gms. pure aniline chloride in 1,000 c.c. HCl (Gr. 1.2); *B*, the same except that the HCl is of Gr. 1.145. Test one drop or 1 c.c. of the solution with 1 to 4 c.c. of solution *A*, a violet coloration changing to blue indicates $HClO_3$. The coloration is also produced by Cl, H_2O_2, MnO_2 and other oxidizing agents. In their absence, the coloration is proportional to the $HClO_3$ present. Reagent *A* is used when 5 c.c. contain 0.5 to 7 mgms. chlorate, Reagent *B* when 5 c.c. contain 0.1 to 2 mgms. chlorate. The solutions are tested in 5 c.c. lots, the colors being compared with those obtained from standard solutions of $KClO_3$. When *A* is used allow 25 minutes, with *B* 15 minutes, before reading off.

Iodides in Waters, etc. Bugarszky and Horvath (*Zts. anorg. Chem.*, LXIII., 184). The solution should contain not over 0.012 gm. I and should be made very slightly acid with dilute H_2SO_4; the proportion of acidity should not be over N/100. 50 c.c. of saturated Br water are added, and the whole bulk brought up to 100 c.c. Allow the flask to stand for an hour in a boiling water-bath. Then transfer to a larger vessel and boil out the excess of Br as rapidly as possible. The reaction occurring is $I_2 + 5Br_2 + 6H_2O = 2HIO_3 + 10HBr$. Cool, add 1 to 2 gms. KI, and acidify with H_2SO_4 or HCl. After standing two or three minutes, titrate with standard $Na_2S_2O_3$. One sixth of the I thus found represents the amount originally present. Chlorides, bromides,

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nitrates or ammonium salts do not interfere with the accuracy of the method.

Cyanogen Determination. Borelli (*Gaz. Chim. Ital.*, XXXVII., 429). In the case of Hg compounds or others not readily dissociated, add an excess of NaOH and metallic Al in powder. The proportions to be used are: for one, atom of Hg 12 to 15 mol NaOH and 4 to 5 at. Al. After filtering or decanting from the Hg, the Cr can be determined by Liebig's method ($AgNO_3$ titration).

Cyanide Solutions from treatment of ores containing copper. Green (*Inst. Min. and Met.*, Bull. No. 49, Oct., 1908). The ores are treated for Au and Ag. This mode of testing is applied in several plants in Mexico.

The solutions required are: $AgNO_3$, 13.05 gms. per liter; $HgCl_2$, 20.846 gms. per liter; $K_2Mn_2O_8$, 3.18 gms. per liter (tenth normal); NH_4CNS, approximately equal to $K_2Mn_2O_8$ solution; $ZnSO_4$ (crystallized), approximately 10 per cent.; $K_4FeCy_6 \cdot 3H_2O$, 42.2 gms. per liter (tenth normal).

1. To 10 c.c. of the solution add a fragment of KI and a few drops of soda (NaOH ?), titrate with $AgNO_3$ to permanent yellowish cloud. No. of c.c. used = a = alkaline cyanide in terms of $KCy + ZnK_2Cy_4$.

2. Dissolve a fragment of KI in a little water, add 5 c.c. K_4FeCy_6 solution, then a pinch of $NaHCO_3$. Run in $HgCl_2$ solution drop by drop until the red precipitate is just permanent. Then add 10 c.c. of the solution to be tested, and titrate with $HgCl_2$ to a permanent red coloration. C.c. used = b = $KCy + ZnK_2Cy_4$ + cuprous K cyanide + ¾ cupric K cyanide. (Ag if present gives a light yellow color before the end point, which in such a case will be dark orange. If much Ag is present, the KCy combined with it must be calculated and deducted.)

3. To 10 c.c. of the solution add 20 c.c. NH_4CNS and 5 c.c. $ZnSO_4$. Titrate with $HgCl_2$ until the precipitate holds a faint yellow tinge. C.c. used = c = $KCy + ZnK_2Cy_4$ + ½ cupric K cyanide.

4. To 10 c.c. of cold rather strong H_2SO_4 add 10 c.c. $K_2Mn_2O_8$ and titrate with the solution to be tested. Calculate the reducing power of 10 c.c. of the solution in terms of $K_2Mn_2O_8$ = d = $KCyS_1 + K_4FeCy_6$ + Cu. (Sulphides and organic matter interfere with the accuracy of this result.)

5. To 25 c.c. of solution add 5 c.c. K_4FeCy_6, acidify with H_2SO_4, add 5 c.c. $ZnSO_4$ and dilute to 50 c.c. Shake up and filter through a dry paper. Titrate 20 c.c. with $K_2Mn_2O_8$ = e = KCyS only.

Then $KCy + ZnK_2Cy_4 = a \div 10$ per cent.

Cupric double cyanide = $c - a \div 5$ per cent.

Cuprous double cyanide = $(a + 2b - 3c) \div 20$ per cent.

KCyS = $e \times 0.0162$ per cent.

$$K_4FeCy_6 \cdot 3H_2O = d - \left(\frac{2b - a - c}{2.6}\right) - 3 \times 0.422 \text{ per cent.}$$

Total Cu = $(2b - a - e) \div 40.9$ per cent.

Titration of Sulfocyanate with Permanganate. Grossmann and Hölter (*Chem. Ztg.*, XXXIII., 348). Experiments show that only about 95

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per cent. of the sulphocyanate is oxidized. This may be due to volatilization of HCNS or to formation of some unknown S compound.

Sodium Sulfide. Tschilikin (*Zts. Anal. Chem.*, XLVIII., 456). Dissolve 15 gms. in 500 c.c. of air-free water, and allow to stand twelve hours. Filter off FeS, etc., and bring filtrate and washings to 1000 c.c. To 10 c.c. of this solution, add 200 c.c. of water and 50 c.c. N/10 I acidify with H_2SO_4 and titrate with N/10 $Na_2S_2O_3$. This shows sulfide + thiosulfate. To another 10 c.c. of the diluted solution add 5 gms. $CdCO_3$ — dilute, acidify with H_2SO_4, let stand 15 minutes and filter. Treat the filtrate with N/10 I and N/10 Na_2SO_3 as before. Result = thiosulfate. The sulfide is then found by difference.

Nitrates in Presence of Bromides. Qualitative. Velledieu (*J. Pharm. Chim.*, XXX., 66). The Br is removed by adding a little basic lead acetate, and from the filtrate the excess of Pb is removed by boiling and adding some pulverized Na_2SO_4. The free SO_4 test can then be applied, whereas in presence of much bromide the strong H_2SO_4 used may set Br free and obscure the reaction.

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ABSTRACTS OF RECENT MINING DECISIONS.*

LOCATION OF CLAIMS.

MINERAL LAND — WHAT CONSTITUTES.

It is not sufficient to render lands valuable for mineral, under the United States statutes, reserving from sale lands valuable for minerals, that there is some trace of mineral, on such land, but there must be minerals in such quantities as to justify the expenditure and effort to recover them. However it is not necessary that minerals of sufficient amount and value to allow immediate profitable working be shown to exist in the land, but it is enough if the vein or deposit has a present or prospective commercial value.

Madison *v.* Octave Oil Co., (Cal.) 99 Pacific 176, December, 1908.

DEFECTIVE LOCATION NOTICE GIVES COLOR OF TITLE.

Where in an action to quiet title to a mining claim against a prior location, a discovery was not proved, a defective location notice was held a sufficient color of title, when coupled with possession gained under a peaceful entry, to warrant a recover and where it appeared that the defendant had no legal rights in the disputed ground.

Protective Mining Co. *v.* Forest City Mining Co., (Wash.) 99 Pacific 1033, February, 1909.

EFFECT OF DISCOVERY BEFORE NOTICE OF LOCATION.

The fact that mineral is not discovered on a claim until after the notice of location is posted, and the boundary marked, is immaterial, where there have been no intervening rights, and where the discovery is the result of work subsequently done by the locator, his possessory rights under his location are complete from the date of such discovery.

Protective Mining Co. *v.* Forest City Mining Co., (Wash.) 99 Pacific 1033, February, 1909.

LOCATION OF MINING CLAIM — RECORDING NOTICES.

The United States statutes specifying the requirements of records of mining claims does not require the recording of location notices; this matter is left to local legislation or to regulation by the miners.

Sturdevant *v.* Vogal, 167 Federal 448, February, 1909.

LOCATION OF MINING CLAIM — EFFECT OF ERROR IN NOTICE.

An error in the location notice of a mining claim in its reference to the location of a permanent monument, was held not material in an

*Prepared for the SCHOOL OF MINES QUARTERLY, by J. W. Thompson, Attorney-at-Law, Indianapolis, Indiana.

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action between the original locator and the subsequent locator, where it was shown that the claim was properly marked by stakes, and where it further appeared that such subsequent locator never saw the notice and could not have been misled thereby.

Sturdevant *v.* Vogal, 167 Federal 448, February, 1909.

LOCATION OF MINING CLAIM — RECORDING NOTICE.

The statute of Alaska includes in its provision the recording of notice of mining location. But the following provision "provided notice of location of mining claims shall be filed for record within ninety days from the date of the discovery of the claim described in the notice," was held not to require but merely permitted the recording of such notice, nor did it provide that the failure to provide such notice should work a forfeiture of rights; and such a forfeiture does not follow in the absence of a well-established rule or custom of the miners of the district to that effect.

Sturdevant *v.* Vogal, 167 Federal 448, February, 1909.

LOCATION OF PLACER CLAIMS — RIGHTS OF INNOCENT LOCATORS.

Where the location of an association placer mining claim was decided to be invalid because of the fraud on the part of some of the locators, if the required assessment work had been kept up and the law and district regulations complied with, the locators who were not implicated in the fraud, but acted in good faith had the right to select and hold their proportionate part of the land within the limits of the association claim.

Cook *v.* Klonos, 168 Federal 700, March, 1909.

MINING CLAIMS — APEXING VEINS.

The owner of a lode mining claim has the right to the ore beneath the surface of his claim in a vein not having its apex there, subject only to the right of the owner of the claim where such vein apexes to follow it downward on its dip.

Mammouth Mining Co. *v.* Grand Central Mining Co., 29 Supreme Court Rep. 413, March, 1909.

LOCATION OF MINES — DISCOVERY SHAFT.

Where the original discovery shaft on a lode mining claim was sunk 10 feet in depth, as required by law, and the portion within the boundaries of the claim was large enough to enable the miner to work within the boundaries, the fact that a part of such shaft was in ground operated on an adjacent patented claim was immaterial. The fact that the shaft was partly within the boundaries of another claim was of no consequence where that portion which was within the boundaries of the disputed claim was of such dimensions as that it was in reality a shaft sunk upon that ground. The law does not attempt to prescribe the extent of any dimension of the discovery shaft, except the depth.

Nichols *v.* Williams, (Mont.) 100 Pacific 969, April, 1909.

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CONFLICTING RIGHTS.

POSSESSION OF MINING CLAIM — PRESUMPTION AND BURDEN OF PROOF.

The owner in fee of a patented lode mining claim is presumed to be in possession of the surface included in the lines of the location and the burden of proving the contrary rests upon one claiming any part thereof by adverse possession.

Original Consol. Mining Co. *v.* Abbott, 167 Federal 681, August, 1908.

QUIETING TITLE TO MINING CLAIM — EVIDENCE.

In an action to quiet title to a placer mining claim the evidence showed that the plaintiff had located the claim, marked its boundaries by stakes and monuments, put up and recorded a proper location notice, and then went into peaceable possession thereafter sinking two shafts to bed rock, and that gold was first discovered at a depth of seventy-two feet; that there were no other excavations on the claim except a hole a foot or so in depth. This was said to be sufficient prima facie proof to show that at the time such location was made the ground was unappropriated public land of the United States, its mineral character being admitted, although the proof also showed that there were other stakes and location notices within the limits of the plaintiff's claim; but which were not shown to belong to the defendant; but this alone could not affect the plaintiff's title as a discovery was essential to a valid prior location.

Cook *v.* Klonos, 164 Fed. 529, October, 1908.

MINING CLAIM — QUIETING TITLE.

A person seeking to quiet title to a mining claim against a prior locator is not required to allege that he had actually discovered minerals on the claim; nor is he required to excuse the absence of such allegations by alleging that his location notices showed that his act was a relocation of abandoned ground. In such case it is sufficient to allege ownership and possession and the adverse claim of the defendant.

Protective Mining Co. *v.* Forest City Mining Co., (Wash.) 99 Pacific 1033, February, 1909.

FAILURE TO MARK BOUNDARIES OF MINING CLAIM.

When the purchaser of a mining claim took it without defined boundaries, and during the continuance of his claim erected no monuments or corner posts, so that the boundary lines of his claim could be readily traced, he assumed at his own peril the risk of intervening rights of third persons.

Protective Mining Co. *v.* Forest City Mining Co., (Wash.) 99 Pacific 1033, February, 1909.

TITLE TO MINERALS — ADVERSE POSSESSION.

A person claiming title to minerals as surface owner, after a severance from the surface ownership, must show actual, notorious, exclusive, con-

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tinuous peaceable and hostile possession of the mine, independent of his possession of the surface in the same manner as a stranger. Such actual possession may be shown by opening and operating the mine, and the possession is continuous if the operation is carried on at such seasons as the nature of the work permits or the custom of the community requires, if there is some proof to possession during an interval to connect the operation, when resumed, with the prior operations.

Gordon *v.* Park, (Mo.) 117 Southwestern 1163, April, 1909.

CONVEYANCE OF MINERALS — RIGHT TO SURFACE.

The grant of coal or the conveyance of a coal mine, under the surface, carries with it the use of the surface so far as it is necessary to carry on mining operations.

Gordon *v.* Park, (Mo.) 117 Southwestern 1163, April, 1909.

MINING LEASES.

LEASE OF MINE — TRANSFER — CONDITION SUBSEQUENT.

The lessees of a mine agreed with a certain person to transfer the lease to a corporation to be organized by him, in consideration that he would contribute as capital a certain sum within a certain time and an additional amount at a later date, such agreement being for the express purpose of raising money to continue the business. In an action to rescind the lease the court decided that the promise of such third person to contribute the amount of money promised was a condition subsequent, the failure to perform which was sufficient to justify a rescission of the transfer of the lease, and that the remedy of the lessor for damages was inadequate.

Schneider *v.* Miller, 113 New York Supplement 399, December, 1908.

OIL AND GAS LEASE — CONSTRUCTION.

A written instrument granting all the oil, gas, coal and asphaltum under certain described land, which was denominated a lease, and had a definite term of years and provided for the payment in cash of a stated amount, and also for the payment of a royalty on all oil produced was construed to be a lease and not a conveyance in fee of the mineral in place.

Moore *v.* Sawyer, 167 Fed. 826, January, 1909.

CONSTRUCTION OF OIL LEASE.

Land owners granted to a lessee the exclusive right to enter on certain lands, to drill wells, mine, and to do all that was necessary and proper for the development and extraction of oil, etc., with the privilege of passing over such lands and of maintaining necessary structures thereon for the objects of the lease: to hold the premises for twenty years, unless otherwise terminated, the lessee to have the right to abandon the lease at any time that it was deemed unprofitable to operate; the lessee to pay a stipulated royalty for all oil produced. Such a lease was held to vest no present title in the lessee to a stratum of the land in place, but

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left the title to the oil in the land owner until it was brought to the surface, vesting in such lessee an estate for years for the purpose of taking oil therefrom, giving the lessee the right to extract and remove the oil from the premises, and which constituted for the time a servitude on the land.

Graciosa Oil Co. *v.* Santa Barbara County, (Cal.) 99 Pacific 483, January, 1909.

OIL LEASE — PRIORITY.

An assignee of a second oil lease on Indian land who took the assignment of such lease with knowledge that a prior lease was outstanding, but which had been forwarded to the land department for cancellation at the request of the parties, was not regarded as a bona fide purchaser entitled to preference over such prior lease, where such prior lease was not in fact cancelled, but was approved by the Secretary of the Interior, as the request for cancellation had been made through a mistake which fact the assignee could have ascertained by making inquiry of the parties.

Moore *v.* Sawyer, 167 Federal 826, January, 1909.

CONSTRUCTION OF OIL LEASE.

An oil lease which granted to the lessee the exclusive right to mine for and produce oil and natural gas from a certain tract of land and which granted the possession of so much of such land as might be necessary therefor, did not give the lessee the right to use any portion of the land for cultivation, or for residences and conveniences for employes, but confined the occupancy and use of the surface to so much of such land as was strictly necessary for mining and producing purposes.

Fowler *v.* Delaplain, (Ohio) 87 Northeastern 260, January, 1909.

OIL AND GAS LEASE — CONSIDERATION.

A lease for oil and gas, for a money bonus as consideration, did not bind the lessee to drill for oil or gas or pay money in lieu of doing so; but it left it optional with him to do so or not. The lessor in such a lease could not annul or revoke it merely on the ground of want of mutuality.

Pyle *v.* Henderson, (W. Va.) 63 Southeastern 762, January, 1909.

VALIDITY OF SECOND OIL AND GAS LEASE.

The lessor of land for oil and gas cannot agree that money to be paid thereunder need not be paid when due, and after giving an extension of the time for payment, then declare the lease forfeited, and make another. And such second lease taken with notice of the first is void as against it.

Pyle *v.* Henderson, (W. Va.) 63 Southeastern 762, January, 1909.

OIL AND GAS LEASE — FORFEITURE.

An oil lease provided that it should be void if a well was not completed, or in lieu thereof money paid, within a given time. And where

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the lessor by his conduct clearly indicated that payment would not be demanded when due, and thereby lulled the lessee into a feeling of security, and because of this he did not make payments when due, the lessor was not permitted suddenly, without demand or notice, to declare a forfeiture. In such case a forfeiture will be deemed waived by any agreement, declaration or course of action on the part of the lessor, which was sufficient to lead the other party to believe that a forfeiture would not be incurred.

Pyle *v.* Henderson, (W. Va.) 63 Southeastern 762, January, 1909.

Gas Lease — Method of Surrender.

The surrender of an unrecorded mining lease need not be in writing; any notice is sufficient that definitely informs the lessor that the lease has been surrendered; but the original lease should be redelivered to the lessor or destroyed. But a recorded mining lease can only be surrendered by an entry duly made and acknowledged on the margin of the record, or by an instrument signed and acknowledged by the lessee.

Ward *v.* Triple State Natural Gas & Oil Co., (Ky.) 115 Southwestern 819, January, 1909.

Mining Lease — Acceptance.

A coal lease executed by the life tenant and part of the remaindermen only, and not signed by the lessee, was not accepted and adopted by the parties so as to make it binding where the lessee corporation, by its agents, simply went on the premises to investigate and discovered coal in workable quantities, the lessee never having advised the lessors to that effect nor decided what to do, where it had the option to determine whether it would mine the coal. Neither the life tenant nor remaindermen could have enforced the lease nor could the lessee have done so without signing and electing to proceed to mine coal thereunder.

Greenridge Fuel Co. *v.* Littlejohn, (Iowa) 119 Northwestern 698, February, 1909.

Lease to Mine — Liability of Lessee for Royalty.

The lease of a coal mine stipulated that the lessee should mine not less than 8,000 tons per year, and he was to pay a royalty on that amount, whether mined or not, at five cents per ton, unless he was unavoidably prevented from taking out the coal. In an action for the royalty it was decided that the lessee was not liable where the mine could not be operated; and evidence was proper as to whether the mine could be operated at a profit, and the lessee was justified in abandoning the mine.

Wilson *v.* Big Joe Bluff Coal Co., (Iowa) 119 Northwestern 604, February, 1909.

Oil Lease — Forfeiture.

Where an oil lease provided that a certain number of wells should be put down on a certain tract of land so as to offset wells on adjoining

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lands, and provided that noncompliance would be a ground of forfeiture, such forfeiture can be enforced by a court of equity, though the lessor could recover compensation in damages. And the court on declaring forfeiture could refuse to permit the lessee to remove the casings from the wells drilled, where such casings could not be removed without destroying the wells.

Powers *v.* Bridgeport Oil Co., (Ill.) 87 Northeastern 381, February, 1909.

OIL LEASE — RIGHTS OF LESSOR.

In an action to recover land from trespassers who had drilled oil wells thereon and for an accounting for oil taken, where it was shown that such trespassers had gone into possession under a void assignment of a lease executed by the complainant and had expended large sums of money in a mistaken belief that they had a lawful right to enter upon such land and drill the wells, they were not required to account for the full value of the oil taken after it was produced but only for its value in the ground as measured by the royalty which the complainant was to receive under the lease.

Turner *v.* Seep, 167 Federal 646, February, 1909.

OIL LEASE — WAIVER OF FORFEITURE.

Where, after the violation of the provisions of an oil lease that would justify a forfeiture, the lessor accepted from the lessee a valuable consideration as a full compliance with the conditions of the lease, the transaction constituted a waiver of the prior violations and restored the lease to its original validity and vigor.

Kansas Natural Gas Co. *v.* Harris, (Kans.) 100 Pacific 72, March, 1909.

LEASE OF MINES — FORFEITURE.

Where the owner of lands leased the mineral rights therein to another, on condition that if the property remain idle for thirty successive days, the lease should be void, on condition broken the lessor had a right to treat the lease as null and void, and sue and recover possession.

Trumbo *v.* Persons, (Ky.) 118 Southwestern 916, April, 1909.

OIL LEASE — RESCISSION.

The purchaser of an oil lease is not prevented from maintaining an action for the rescission thereof on the ground of fraud, for the reason that he had used up a part of the oil which he had received from the property, because of his inability to place the purchaser in statu quo. While he had rendered impossible the restoration in specie of all that he had received in the transaction, it was sufficient in such case if he restored or offered to restore its money equivalent; and this is the rule where the property received is used or lost so that it cannot be restored in specie; when its value is capable of being ascertained.

Bayse *v.* Paola Ref. Co., (Kan.) 101 Pacific 658, April, 1909.

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OIL AND GAS LEASE — INJUNCTION — RIGHT TO REMOVE MACHINERY.

Where a person entered upon certain premises to explore for oil and gas with knowledge of the prior right of another, and was enjoined and forfeited all the work done, he was held to have the right to remove such machinery and materials used in drilling and pumping wells, conveying or storing oil not being a part of the wells themselves, which could be removed without injury to the premises.

Gillespie *v.* Fulton Oil & Gas Co., (Ill.) 88 Northeastern 192, April, 1909.

OIL AND GAS LEASE — CONSTRUCTION.

A lease of land to explore for oil and gas, and if found, to produce them, was held to be merely the grant of a privilege to enter and prospect and did not convey title to any oil or gas until found.

Gillespie *v.* Fulton Oil & Gas Co., (Ill.) 88 Northeastern 192, April, 1909.

LEASE OF MINES — RECOVERY FOR EXPENDITURES, &C.

In an action for damages for a breach of contract to sublease lands for mining on the contingency that the sublessees found paying ore, they were held entitled to recover for expenditures made in endeavoring to find such paying ores, though their prospective profits would be too uncertain and speculative as a basis for recovery. The measure of damages in such a case was said to be the actual expenditure incurred in the exercise of their work.

Ragland *v.* Couqueror Zinc Co., (Mo.) 118 Southwestern 1194, May, 1909.

ASSESSMENT WORK.

LOCATION OF MINE — FAILURE TO PERFORM ASSESSMENT WORK — FORFEITURE.

The United States statutes provide that on failure to perform the required assessment work by the locator of a mining claim, the claim shall be open to relocation, provided the original locator has not resumed work on the claim after such failure and before a relocation is made. Under this statute it has been decided in California that a mere failure to comply with the requirements as to the performance of the assessment work did not terminate the right of the locator; that the only effect of such failure was to throw the land open to location by others; and in the absence of any other location, the original claimant had the right to resume work and hold his claim. And this right and his estate is not devested until there has been a peaceable entry for the purpose of relocation by another person.

Madison *v.* Octave Oil Co., (Cal.) 99 Pacific 176, December, 1908.

LOCATION OF MINE — FAILURE TO PERFORM ASSESSMENT WORK — ADVERSE POSSESSION.

A person who enters upon the mining claim of another during the year within which the owner of the claim is required to perform the

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assessment work, and who holds or claims possession thereto, adversely to such original holder, will not be heard to object that such original holder had not performed the annual work required by law.

Madison *v.* Octave Oil Co., (Cal.) 99 Pacific 176, December, 1908.

MINING CLAIM — PERFORMANCE OF ASSESSMENT WORK.

The payment of a large sum to persons employed in good faith to perform assessment work on a mining claim was insufficient to prevent a forfeiture for nonperformance of such work, where such person did no more than enter upon the ground and make a pretense of doing the work.

Protective Mining Co. *v.* Forest City Mining Co., (Wash.) 99 Pacific 1033, February, 1909.

LIABILITY OF INJURY TO MINER.

LIABILITY OF OWNER OF MINE FOR INJURY TO EMPLOYEE OF A CONTRACTOR.

Where a contractor was working a portion of a mine under a contract with the owner under which he mined the ore at a stated price, and the owner retained control of the mine and had the duty of inspecting and keeping the mine in safe condition, an employee of such contractor was not a trespasser, nor a mere licensee, but was said to be there by invitation of the owner, and as to him the owner must exercise ordinary care and prudence to render such mine reasonably safe.

Tennessee Coal, Iron & Railroad Co. *v.* Burgess, (Ala.) 47 Southern 1029, December, 1908.

INJURY TO MINER — LIABILITY FOR FAILURE TO KEEP MATERIAL.

Under a statute providing that the superintendent of a mine shall at all times keep on hand at the mine materials necessary to preserve the health and safety of the employees as ordered by the mine foreman, it was decided in an action for damages for injury to a miner that, unless it appeared that the mine foreman had made a proper requisition for the materials, and it had been refused, or that the owner or superintendent of the mine had failed to keep on hand the necessary materials, or supplies, the owner of the mine was not liable. To make the mine owner liable for injuries caused by an explosion of gas, on the ground of negligence in failing to furnish proper material, it must be shown that such negligence was the cause of the injury.

Bisko *v.* Brasnel Coal Co., (Pa.) 72 Atlantic 504, January, 1909.

INJURY TO MINER — CONTRIBUTORY NEGLIGENCE.

Where a coal mine was so free from gas that lamps were used, but there was an accumulation of gas in a particular pocket, a miner sent to work in that particular place, and who approached the same with an open light, was not entitled to recover for injuries received by an explosion from gas igniting by his light; where he knew that there was

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an accumulation of gas in the particular entry and approached the same with an open light he assumes the risk incident to the service.

Bisko *v.* Brasnel Coal Co., (Pa.) 72 Atlantic 504, January, 1909.

MASTER AND SERVANT — DUTY TO LIGHT MINES.

A coal miner approaching the bottom of the shaft from above with a view of leaving the cage, or approaching the bottom of the shaft from his working place below with a view of entering the cage, is within the protection of the Illinois statute which provides that so long as there are miners underground the operators shall maintain sufficient light at the bottom of the shaft so that persons coming to the bottom may discern the cage and objects in the vicinity.

Robertson *v.* Donk Brothers Coal & Coke Co., (Ill.) 87 Northeastern 373, February, 1909.

INJURY TO MINER — INCOMPETENT SERVANT.

The owner of a mine was held liable for injuries to a miner from the negligence of another employee acting as hoisting engineer, where such engineer was incompetent and was hired as a fireman and was required to leave that work and act as engineer as the occasion required during the night shift when no regular engineer was present.

Layzell *v.* J. H. Somers Coal Co., (Mich.) 120 Northwestern 996, April, 1909.

COAL LANDS.

ENTRY OF COAL LANDS — EXCESSIVE AMOUNT.

Persons entitled under the United States Statute to a preferential right of entry of coal lands are prohibited from making more than one entry by the same person and from entering such lands apparently for themselves, but in fact as agent for another who has already purchased the full quantity permitted by law.

United States *v.* Forrester, 29 Supreme Court 132, October, 1908.

ENTRY OF COAL LANDS — CRIMINAL CONSPIRACY.

The statutes of the United States make criminal a conspiracy to obtain title to public coal lands with the purpose of defrauding the United States in any manner or for any purpose.

United States *v.* Keitel, 29 Supreme Court 123, October, 1908.

ENTRY OF MINE FOR DISQUALIFIED PERSON.

The United States statutes prohibit a qualified person from entering coal lands apparently for himself, but in reality as the agent for a person who is disqualified by reason of having already entered the full quantity permitted by law.

United States *v.* Keitel, 29 Supreme Court 123, October, 1908.

GRANT OF COAL — SUPPORT OF SURFACE.

A grant of all the coal or other mineral lying or being in, upon or under certain described land, did not deprive the grantor of the right to

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surface support. In the absence of waiver the grantor is entitled to have the surface reasonably supported by the coal stratum granted; and such right is not waived by a provision that all the mining rights and privileges are to be used without liability for damages from the use thereof. And the giving to the grantee the right to sink air shafts, erect buildings for pumping stations, etc., and providing that such mining operations should not interfere with the surface of the land, the surface rights not thus expressly granted, including sufficient support, were reserved.

Dignan *v.* Altoona Coal & Coke Co., (Pa.) 71 Atlantic 845, January, 1909.

Construction of Coal Lease.

A coal lease provided that the lessee should pay a certain price for all coal that would pass over a screen of an eighth of an inch mesh, and that all that passed through should be classed as culm, and in case of sale of such culm, the lessee should pay one tenth of the net profit to the lessor. In an action to recover the lessor's part of the profit on the culm, it was decided to be a question for the jury whether the entire cost for mining coal and culm was to be considered, or whether it was impossible for the lessee to prepare the royalty coal for market without producing culm, and that when sold the entire price less the cost of loading such culm was the net profit.

Woodruff *v.* Gundon, (Pa.) 71 Atlantic 849, January, 1909.

Mining — Injury to Surface.

The rule is that the owner of mineral must so mine it as not to injure the surface, where there is no agreement or stipulation to the contrary; but this rule applies only to the surface soil, and not to wells and springs that are fed by subterranean streams.

Sloss-Sheffield Steel & Iron Co. *v.* Sampson, (Ala.) 48 Southern 493, January, 1909.

Regulation of Coal Mine — Construction of Statute.

The statute of Indiana (Laws, 1907, p. 334) makes it unlawful for the owner, lessor, or operator of any coal mine within the state to make, dig, construct, or cause to be made any entry or trackway — in any coal mine where drivers are required to drive with mine cars, unless there should be provided on both sides of the track, at least two feet in width from the rail, a space free from props, loose slate or other obstructions, so that the driver may have a safe place. The act also exempts certain fields of coal in the block coal fields. On the construction of this statute by Supreme Court of the state it was decided that from the entire statute and the enacting clause it was not intended to be operative as to any class of coal mining unless the block coal fields were not embraced: and that the statute was intended to be applicable in its entirety so as to exclude the block coal fields and that the legislature had the power to make the classification and exception.

State *v.* Barrett, (Ind.) 87 Northeastern 7, February, 1909.

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COAL LANDS — RIGHT TO COAL REMOVED DURING DEVELOPMENT WORK.

Under the United States statutes a qualified person who, in response to the government's invitation, enters upon public lands in search of coal deposit and who expends time, labor and money in an honest effort to open and develop a coal mine when found and with the intention of purchasing the lands according to the statute, if the coal discovered proves to be such as to give character and value to such land, was said not to be a trespasser, but on the contrary was in the exercise of a privilege conferred by law and entitled to such coal as was taken out and removed as an incident only to the reasonable prosecution of that work.

Ghost *v.* United States, 168 Federal 841, March, 1909.

MISCELLANEOUS.

MONOPOLIES — COMBINATIONS BY MINING CORPORATIONS.

A Michigan mining corporation engaged in mining and refining copper wholly within that state by purchasing stock and obtaining proxies from other stockholders secured a voting control of a majority of the stock of a similar corporation operating adjoining mines. The purchasing corporation proposed to use such control to place in its directory a majority from its own board of directors. It was held to have the right to do this under the laws of the state, and it did not directly or necessarily affect interstate or foreign commerce and that such control, was not of itself illegal as a condition in restraint of trade in violation of the Sherman Anti-Trust Act, especially in the absence of proof of an unlawful intent to so use its power as to bring about the prohibited restraint or monopoly, and not in a lawful way to use it in an economical management of both companies.

Bigelow *v.* Calumet & Hecla Min. Co., 167 Fed. 704, 721, October, 1908.

CONTRACT TO CONVEY MINING CLAIMS — CONSTRUCTION.

A contract to convey certain specified placer mining grounds, described a part as patented and a part as mineral entries for which receiver's receipts had been issued, "patent not yet issued, but to be issued," and the vendee was afterwards put in possession in accordance with the contract. Such contract was construed to be one to convey such title to the several claims, legal or equitable, as the seller then had, and that this was fully understood by the parties to the contract. And the words "patent not yet issued, but to be issued," were construed as merely descriptive and not words of covenant and did not bind the seller to convey a patent title. The fact that patents for such unpatented claims had not been issued at the time the purchaser was to make final payment and receive the deed did not afford ground for rescission by him.

Nelson *v.* Wood Placer Mining Co., 167 Federal 206, November, 1908.

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MINING — ADJACENT CLAIMS — DEVELOPMENT WORK.

Where several persons hold different mining claims which are adjacent, and work, beneficial to all, can best be done on one of them; under a proper agreement between the owners the development work can all be done on one and credited to the several claims, where such work constitutes a general plan or scheme for the development of the several claims. It is the rule that development work may be done outside the limits of the claims, and be credited thereon if beneficial to all the claims, for which the credit is asked, provided the claims are held in common.

Hawgood *v.* Emery, (S. Dak.) 119 Northwestern 177, January, 1909.

FORFEITURE OF CLAIM — DEVELOPMENT WORK.

One of two partners or owners in common of two or more claims, cannot prevent a forfeiture of his rights by his copartner by showing that he had performed work on adjacent claims, beneficial to the claims in litigation, he being the sole owner of a part of such adjacent claims, and the owner in common with third persons of the other claims on which the work was done, — in the absence of an agreement between them for the doing of such work, or a sufficient showing that the work was part of a general plan or scheme for the development of the claims owned by such partners in connection with those on which the work was done. The reason of this is that one partner cannot, in the absence of an agreement, perform work on property in which his copartner is not interested, and hold his copartner liable therefor.

Hawgood *v.* Emery, (S. Dak.) 119 Northwestern 177, January, 1909.

APPROPRIATION OF LAND BY A RAILROAD — RIGHT OF OWNER OF MINERALS.

A railroad company appropriating land for its right of way or other purposes secures not only the surface, but also so much of the underlying minerals as may be necessary to properly support the surface for its use. And where the owner of the surface had prior to such appropriation by the railroad, conveyed the underlying coal with sufficient mining rights to enable the grantee to remove it, regardless of its effect upon the surface, such grantee was entitled to be compensated by the railroad company for any part of the coal necessary for the support of the surface.

Diltz *v.* Plumville R. Co., (Pa.) 71 Atlantic 1072, January, 1909.

MINING CONTRACT — NATURE AND CONSTRUCTION.

A contract in consideration of one dollar and of a royalty, granted to the obligee all the bituminous rock and other minerals he might choose to mine, quarry and take from certain lands; it further provided that in case the lands failed to produce minerals in paying quantities or of good quality, the obligee might, upon thirty days notice in writing to the obligor, relinquish his rights, and that the obligee should pay royalty on 300 tons annually, whether taken or not. In the performance of the

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contract the obligee quarried and took away 27 tons of rock, and conducted no further operations to the time of his death, fifteen years later, though he paid royalty for two years. In an action between the obligor and the heirs of the obligee, it was decided that the contract was not a grant of land nor a lease, but was a grant of a right only, and that all the rights of the obligee and consequently of his heirs were extinguished by the voluntary abandonment of the right, and that the obligor waived the thirty days' written notice required.

Payne *v.* Neuval, (Cal.) 99 Pacific 476, January, 1909.

Power of State to Regulate Mineral Springs.

A state under the doctrine of police powers may regulate the use of mineral and carbonic acid gas wells and prevent waste and detriment to neighboring proprietors who procure water and gas from the same source.

Hathorn *v.* National Carbonic Gas Co., (N. Y.) 87 Northeastern 504, February, 1909.

Rights in Subterranean Mineral Waters.

Subterranean mineral waters are regarded in law as minerals in respect to their use and enjoyment without reference to the quantity of salts and gas which may be in solution. An adjoining proprietor was entitled to equitable relief independent of any statute to prevent another proprietor from increasing the flow of percolating mineral waters and gas by means of pumps, so that he obtained a greatly increased proportion of a common supply at the expense of such adjoining proprietor for the purpose of supplying a public market with gas, and turning the mineral water to waste.

Hathorn *v.* National Carbonic Gas Co., (New York) 87 Northeastern 504, February, 1909.

Joint Agreement to Purchase Mining Claim — Purchase by One After Expiration of Option.

A prospective purchaser contracted with two persons who held an option for a mining concession in Mexico that if they would get an extension of the option in order to give time for the sinking of a shaft he would furnish the necessary money therefor. The holders of the option secured its extension on condition that an advance payment of $5,000 should be made and demanded payment of the other party of his share of such advance payment, which was refused, and thereupon the holders of the option permitted it to expire. Subsequently one of them immediately obtained a new option to himself under which he afterwards purchased the property. In an action by such third person to establish a trust in the property, it was decided that the contract created no such fiduciary relation from treating it as at an end, and that a subsequent purchase by one raised no resulting trust in favor of such prospective purchaser.

Gaines *v.* Chew, 167 Federal 630, February, 1909.

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MINING CLAIM IN FOREIGN COUNTRIES — APPLICATION OF STATUTE.

The United States statutes governing the rights of co-owners of mining claims where a part of such owners have done all the assessment work thereon, have no application to mining property situated in a foreign country.

Gaines *v.* Chew, 167 Federal 630, February, 1909.

CONTRACT FOR SALE OF MINES — PAYMENT AND POSSESSION.

A contract for the sale of mines permitted the purchaser to take possession and develop such mines, and provided that part of the proceeds should be paid on the purchase price by depositing in a bank the net proceeds from the sale of the ore within fifteen days after receipt thereof, and on his failure to do so the deed placed in escrow should be returned. In an action for damages for dispossession on the failure to make such deposit, the court decided that the contract was entire and that the purchaser's right to remain in possession of the mine depended upon the deposit of the proceeds of the ore as required.

World's Fair Min. Co. *v.* Powers, (Ariz.) 100 Pacific 957, March, 1909.

PURCHASER OF MINING CLAIM — NO RESCISSION FOR FRAUD.

The purchaser of mining claims was not entitled to have the contract rescinded on the grounds of false representations made by the vendor, where the deal was not closed until three months after the purchaser sent mining experts to examine the property, thereby giving the means of readily acquiring knowledge of the alleged falsity of the representations.

Mitchell Min. Co. *v.* Hammons, (Ariz.) 100 Pacific 695, March, 1909.

INJUNCTION TO PREVENT TAKING AND SELLING ORE.

Where it appeared from the decisions in prior litigation that a mining company would, in a pending action, probably recover a large judgment against another mining corporation for the value of ore extracted from mines owned by the complainant, a court was authorized to grant an injunction restraining the defendant company from extracting or selling any more ore from the mine and where it was shown also that the defendant mining company would not have sufficient mining property remaining to satisfy the judgments that might be rendered.

Montana Min. Co. *v.* St. Louis Min. & Mill. Co., 168 Fed. 514, March, 1909.

INJUNCTION TO PREVENT DISCHARGE OF MINERAL WASTE IN STREAMS.

The owner of arid agricultural lands, who has a right to use the wa of a river for the purpose of irrigation, has such an interest in the wa different from that of the general public as entitled him to maintain action to restrain a mining company from throwing its deposits

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mineral refuse in streams tributary to such river which would render the water unfit for use.

Arizona Copper Co., *v.* Gillespie, (Ariz.) 100 Pacific 465, March, 1909.

DEED — RESERVATION OF MINERALS.

In a deed conveying certain lands a reservation of "all minerals" was held to include petroleum, oil and gas.

Weaver *v.* Richards, (Mich.) 120 Northwestern 818, April, 1909.

CONVEYANCE OF MINERALS — CONSTRUCTION.

A bare conveyance of minerals does not create a special and distinct estate in a technical sense; it only separates a part of the property from the remainder and the right to ownership and control of such minerals is consistent with all other rights of ownership to the surface and other parts of the land. It accordingly follows that where a mineral which has been conveyed was removed from the land, the owner of the mineral ceased to have any further rights in such land. It is also the rule that a grantee of minerals has no way of necessity over the land of a stranger to remove such minerals.

McBurney *v.* Glenmary Coal & Coke Co., (Tenn.) 118 Southwestern 694, May, 1909.

CONVEYANCE OF A SPECIFIC MINERAL — EFFECT.

Where the owner of land conveys a particular mineral by a specific term, and not by a general term, the rule is that such particular mineral alone will pass, and that all other minerals remain as the property of the owner of the land.

McBurney *v.* Glenmary Coal & Coke Co., (Tenn.) 118 Southwestern 694, May, 1909.

OIL WELLS — LIABILITY OF OWNER FOR POLLUTION OF STREAM.

The owner of an oil well is not liable for injuries to real estate bordering on a stream, the waters of which were polluted with oil and salt water, where such pollution was necessary to the enjoyment of the well, and where it was shown that the owner of the well had exercised due care to avoid the injury and was not actuated by malice. The question for the jury to determine was whether the owner of the well had made a reasonable use of it and had exercised diligence to prevent the injury.

Ohio Oil Co. *v.* Westfall, (Ind.) 88 Northeastern 354, May, 1909.

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INTERNATIONAL CONGRESS OF MINING, METALLURGY, APPLIED MECHANICS, AND PRACTICAL GEOLOGY, DÜSSELDORF, 1910.

The International Congress of Mining, Metallurgy, Applied Mechanics, and Practical Geology, held at Liege in 1905, resolved at the closing meeting on July 1 of that year to accept the invitation of the Rhenish-Westphalian Mining Industry to hold the next congress in Rhenish-Westphalia.

Acting upon this resolution, the congress will be convened at Düsseldorf, the last week in June, 1910, having been fixed as the date. The congress will be divided in the following sections: (1) Mining, (2) Metallurgy, (3) Applied Mechanics, (4) Practical Geology.

The following extracts from the by-laws of the congress will indicate the objects of the organization:

Participants in the congress may be: (*a*) Honorary members; (*b*) patrons of the congress, that is, contributors of not less than 100 marks (£5) to the funds; (*c*) ordinary members, who pay a subscription of 20 marks (£1) for membership of any one of the four sections. These may participate in the proceedings of any other sections by making a further payment of 5 marks (5 s.) for each section.

The condition of membership named under (*c*) is the scientific or practical occupation in one of the four working branches.

An application to join is regarded as an undertaking to observe the by-laws of the congress. All participants will receive a card of membership. All participants may also offer papers and take part in the discussions at meetings of the congress and of the sections.

The organization committee is charged with the work of arranging for visits and social entertainments. This committee will be responsible for the conduct of the business of the congress and for the printing of the reports, and it will continue in office until the winding up of all matters connected with the congress.

The work of the congress will be performed: (*a*) In general meetings; (*b*) in sectional meetings, for the purpose of discussing important problems relating to mining, metallurgy, applied mechanics, and practical geology; (*c*) by making visits to scientific institutions, industrial undertakings, etc., and excursions to districts of geological interest.

The languages authorized to be used at the meetings are German, English, and French. The official language is German, in which notes of the proceedings will be taken and the reports of meetings drawn up.

The Committee of Organization will select the subjects to be presented for discussion. Those members who desire to offer papers or communications to the congress must submit these, at least three months before the opening date, to the Committee of Organization.

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The committee will undertake, as far as possible, to translate into German such papers as are written in a foreign language and are unaccompanied by a German translation.

The Committee of Organization reserves to itself the right to limit the time taken in reading papers and communications. These should in any case be condensed as much as possible, and the time for delivery should not exceed fifteen minutes. Speakers in discussion will be limited to ten minutes each, and it will not be permissible to speak more than twice on the same subject.

All papers must, as far as possible, be available beforehand for those who desire to receive a copy. No paper may be read at the meetings the contents and conclusions of which have not been submitted to the Committee of Organization at least a month before the opening of the congress, and by them placed upon the agenda. After the conclusion of the business on the agenda, however, the president of any section may at his discretion accept papers and communications which have not previously been submitted.

To facilitate the careful compilation of the reports, every speaker is requested to hand in to the secretary of the section, within two hours of the close of the meeting, a short draft of his remarks, which may be written in any one of the three authorized languages. If the draft is not handed in within the specified time, those who are conducting the business of the section will edit the matter as the sense may require, and deal with it finally. They also reserve the right to shorten the contributions to discussions, where this is practicable without impairing the sense.

The papers, notes, and reports will be published by the Committee of Organization as far as the funds of the congress suffice. The committee also has power to sanction the publication of the papers in the technical press.

Every author will receive fifty complimentary copies of his paper, and can order further copies if he pleases, at his own expense, provided he gives timely notice to the committee before the advance copies are printed off.

All enquiries and communications relating to the congress should be addressed to the: "Arbeitsauschutz des Internationalen Kongresses, Düsseldorf, 1910 (Committee of Organization of the International Congress), Jacobistrasse 3/5, Düsseldorf, Germany."

PROVISIONAL SCIENTIFIC PROGRAMME OF THE VARIOUS SECTIONS.

Section I. Mining.

1. Shaft-sinking, with special reference to the cement processes, freezing processes, and tubbing of shafts at great depths. The lining of shafts with concrete and reinforced concrete.

2. Methods of working, mine supports, with special reference to hydraulic packing, the use of reinforced concrete, the preservation of timber, and lighting of collieries.

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3. Winding and haulage, with special reference to winding ropes, safety-catches and appliances, underground haulage, and haulage from the working faces.
4. Mine drainage.
5. Risks arising from fire-damp, coal-dust, and underground fires, and the methods of combating these.
6. The mechanical preparation of coal and ore, the recovery of by-products, briquetting, and the utilization of low-grade fuels.
7. Recent practice in mine surveying.
8. Statistics.
9. Sanitation and hygiene.

SECTION II. METALLURGY.

A. *Production of Pig Iron.*

1. Coking.
   - (*a*) Ovens.
   - (*b*) Mechanical appliances.
   - (*c*) Recovery of by-products.
2. Ore supply.
   - (*a*) Recent discoveries of ore.
   - (*b*) Recent development and prospects of the ore briquetting processes.
3. Metallurgy of the blast-furnace process.
   - (*a*) Influence of foreign substances.
   - (*b*) Composition of slag.
4. Blast-furnace working.
   - (*a*) Ore conveyance, storage and charging.
   - (*b*) Gas-washing and purification of the waste water.
   - (*c*) Dry air-blast.
   - (*d*) Casting machines and mixers.
5. Utilization of waste products.
   - (*a*) Gases.
   - (*b*) Dust from blast-furnace gases.
   - (*c*) Slag (for hydraulic packing, cement, stone, concrete).

B. *Production of Malleable Iron.*

1. Advances in the methods of the metallurgical treatment of iron and steel.
   - (*a*) Air-blast refining processes.
   - (*b*) Open-hearth refining processes.
   - (*c*) Processes for the production of electro-steel.
2. Production and treatment of special alloys of steel.

C. *Iron and Steel Manufacture.*

1. Improvements in the methods of casting iron and steel.
2. Further treatment of malleable iron.
   - (*a*) Forging and pressing.
   - (*b*) Rolling.
   - (*c*) Fitting.
   - (*d*) Developing of the welding processes.
3. The driving of the rolling-mills considered technically and economically (steam, gas, electricity).

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D. *Testing of Iron and Other Metals.*

1. Chemical testing.
2. Mechanical testing.
3. Metallography and microscopy of metals.

E. *Economics of the Iron Industry.*

1. Iron trade statistics.
2. Labor conditions and labor supply.
3. Patent rights.

F. *Advances in the Metallurgy of Non-ferrous Metals.*

Section III. Applied Mechanics.

1. History of machine construction for mining and metallurgical purposes.
2. Steam raising.
3. Central electric-power stations.
   (*a*) Reciprocating engines (steam, gas).
   (*b*) Turbo-engines.
4. Central condensing plant.
5. Winding engines.
   (*a*) Steam winders.
   (*b*) Electric winders.
   (*c*) Safety and signalling apparatus.
6. Pumping.
7. Fans and air-compressors.
8. Blowing engines for blast-furnaces and steel works.
   (*a*) Reciprocating blowers.
   (*b*) Turbo-blowers.
9. Methods of driving rolling-mills.
10. Rolling-mills and accessories.
11. Conveyors for mining and smelting works.
   (*a*) For materials in bulk (coal or coke).
   (*b*) Special cranes and ladle cars.
   (*c*) Loading and unloading apparatus.

Section IV. Practical Geology.

1. Importance of practical geology in science and political economy.
2. Stratigraphy and genesis of the available mineral deposits. Calculations of their yearly output and resources.
3. Seismology, terrestrial magnetism, and terrestrial heat.
4. Questions relating to hydrology.
5. The utilization of natural sources of water power. Barrages.

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DEPARTMENTAL NOTES.

DEPARTMENT OF MINING.

During the past summer thirty-nine students were engaged in mining field work. The entire class were first given a week's practice in mine surveying at the Orchard Iron Mine, near Dover, N. J. As in former years the students then proceeded, in separate squads or individually, to mines in the West and elsewhere, where arrangements had previously been made and privileges secured for the required note-taking and sketching. Several members of the class obtained positions at mines and worked all summer, in partial or complete fulfillment of the requirements; but most of them devoted all of the allotted time to observation and study. Following are the names of the principal mines and districts visited, and the assignment of squads:

Zinc and lead mines of Joplin and Flat River, Mo., K. C. Browne, E. McCrorken and R. A. McGovern; Butte, Mont., and Bingham Cañon, Utah, H. C. Carlisle, H. W. Nieman, L. A. Parsons and Curtis Pigott, the work being done chiefly at the Pennsylvania Mine, Butte; Michigan Copper Mine, Rockland, Mich., and iron mines of the Marquette district, G. S. de Hieropolis, Jr., V. Mulholland, D. M. Obler and J. E. Rypinski; Cresson Gold Mine, Cripple Creek, Colo., T. B. Counselman, J. Maller and A. G. Marsh; Portland Mine, Cripple Creek, J. Hayes-Davis and A. B. Menefee; the mines of the Copper Range Mining Co., Painesdale, Mich., H. H. Hodgkinson, P. N. Moore, C. F. Schnepp and R. H. Townsend; mines of the Tennessee Copper Co., Ducktown, Tenn., together with short visits to coal and coke plants, F. F. O'Connor and M. L. O'Neale; collieries at Carbondale, Penna., R. E. Phelan, G. H. Ross, W. H. Shearman and J. D. Tallant (Phelan and Ross visiting also coal and coke plants near Connellsville, Penna.); Snowstorm and Bunker Hill and Sullivan Mines, Idaho, W. E. Greenough and R. E. Walters.

The remaining members of the class either worked or studied alone, at the following mines: J. I. Kane, Velardena, Mexico; E. A. McKanna, Copper Queen, Ariz.; G. S. Peyton, Jr., Cinco Estrellas and other mines, near Zacatecas, Mexico; D. L. C. Hover, Leadville, Colo.; F. A. Wardlaw, Jr., Highland Boy, Boston Consolidated and other Utah mines; R. E. McConnell, Esmeralda Mine, Silverton and Portland Mine, Cripple Creek, Colo.; M. L. Lee, Cananea Copper Mine, Mexico; H. L. Carr, Cobalt district, Canada; M. B. Evans, iron mines near Dover, N. J.; A. H. Smith, Wilkes-Barre, Penna. Some of the students last mentioned had partial credit for work done previously. It is regretted that three members of the class failed to fulfill all the requirements of the summer course (either as to time or quality of work done), and will be obliged to make up the deficiency later.

On the whole the work done in the field was excellent and many

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valuable sets of notes and sketches were obtained. In several cases the officers of the mines took great interest in the students' progress, affording them ample facilities for studying all branches of underground and surface operations and plant. To these our hearty thanks are due, specially to Mr. Frederick W. Denton, of the Copper Range Co.; Messrs. Samuel Brady, Superintendent, and Clarence M. Haight, Engineer, of the Michigan Copper Mine ; Mr. N. H. Emmons, of the Tennessee Copper Co.; and above all to Mr. Richard Roelofs, Manager of the Cresson Consolidated Gold Mining Co., Cripple Creek, who gave the squad at his mine frequent quizzes on what they were studying, together with informal talks on other methods of mining. We also desire to acknowledge the kindness of the officers and staff of other mines for privileges extended to members of the class. R. P.

DEPARTMENT OF MECHANICAL ENGINEERING.

(*Extracts from Annual Report of the Head of Department to the Dean of the Schools of Mines, Engineering and Chemistry.*)

1. *Amount and Distribution of Instruction.* — This department in its announcement offered last year forty-five courses of one term length, of which thirty-six were of undergraduate and twenty-nine of graduate grade, all of which were given except three of undergraduate and six of graduate grade. Of those not given the six graduate courses were without applicants, one undergraduate course, designed for sanitary engineers only, was also without applicants, while the other two undergraduate courses could not be given by reason of schedule conflicts resulting from the change of curriculum in one year.

Taking account only of the assigned hours for the courses given the number of student hours for one term was 90,345 (see table), of which 48 per cent. were given to candidates for the degree of mechanical engineer and 52 per cent. to others, indicating that a little more than half the instruction was given to students studying for other than mechanical degrees. Of the total instruction 61 per cent. was given by lecture and recitation and 39 per cent. in laboratory and drafting room, and of the lecture and recitation work 38 per cent. was internal and 62 per cent. external, while for the laboratory and drafting instruction 64 per cent. was internal and 36 per cent. external.

No credit has been allowed in these figures for conferences, which are very numerous, both with students, visiting professors from other schools, practicing engineers, whom we are interesting in the course and with the large number of lecturers who have been assisting in bringing the material of instruction up to date. Nor has any credit been allowed for the time necessary to read, correct and mark some seven thousand laboratory reports and the larger number of note books, one for each student for each course, containing the student's report of his work. Nor has any time been allowed for the writing of lectures, conducting of correspondence with manufacturers for information and the filing of the information; fully one thousand letters of this sort, with replies, have been handled. No account has been taken of the time necessary

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for the writing of papers of a professional character, the taking part in committee work and general meetings of professional societies, the attendance at the university committee meetings and preparation of the

STUDENT HOUR INSTRUCTION, YEAR 1908–1909.

Course No.	Lectures.	Laboratory.	M.E.	Others.	Student Hours for One Week.				Total.
					Mechanical Engineers.		Others		
					Lecture and Recitation.	Laboratory and Drafting.	Lectu e and Recitation.	Laboratory and Drafting.	
11	3		48	4	144		12		156
12	3	3	48	4	144	144	12	12	312
13	3			216			648		648
14	3			216			648		648
17	2		18	91	36		182		218
18	2		18	91	138		182		218
19	6	12	23		92	276			414
22	4	3	23		46	69			161
26	2	3	23		24	69			115
31	1	3	24		17	72			96
32	1	3	17		46	51			68
33	2	3	23	7		69	14	21	150
36		6	56	24		336		144	480
39	1	6	18		18	108			126
40	2	6	16		32	96			128
41	1	3		53			53	159	212
46	3		23	35	69		105		174
52	2		21	8	42		16		58
53	2		23		46				46
54	2		15		30				30
56	1			32			32		32
59	2	3	31	9	62	93	18	27	200
60		3	17	28		51		84	135
61	1		23		23				23
62	1		15		15				15
63		3		32				96	96
66	14		14		296				296
68	2	3	23		46	69			115
72	2	3		44			88	132	220
74	2			63			126		126
76	1	3		28			28	84	112
77	1	3		27			27	81	108
79	3			29			87		87
					1,402	1,503	2,289	840	6,023

SUMMARY.

Total assigned student-hours for one term given to candidates for M.E. degree, lecture and recitation	21,030
Total assigned student-hours for one term given to candidates for M.E. degree, laboratory and drafting	22,545
Total assigned student-hours for one term given to candidates for other degrees, lecture and recitation	34,170
Total assigned student-hours for one term given to candidates for other degrees, laboratory and drafting	12,600
	90,345

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reports, the reading of professional journals and transactions necessary to keep the instructor informed of progress, the inspection of new machinery and the testing of old, forming part of a similar continuance of the instructor's education.

2. *Practicing Engineers as Lecturers.* — During the past year a plan of using practicing engineers as special lecturers has been introduced with success. In some cases these lecturers were in charge of the course and in other cases they lectured for one hour only on some topic forming part of a course, but in every case the instructor sat in the room during the delivery of the lecture, relieving the lecturer of such routine as taking attendance, distributing notes and between lectures conducting recitations. In this way lecturers were prevented from riding a hobby, or when they did make statements which seemed unfair the instructor had an opportunity to correct the false impression during the recitation period. Much credit is due to those broad-minded men for their free contribution of time, effort and their hardly earned data on the subject. In every case the contribution was entirely free of cost to the university and one course of lectures, that on elevating and conveying machinery, was supported by the following manufacturers of this class of apparatus: C. W. Hunt Co., Darley Engineering Co., Dodge Mfg. Co., The Brown Hoisting Machinery Co., Heyl & Patterson, Inc., The Jeffrey Mfg. Co., Link Belt Co., The J. M. Dodge Co.

The plan of using these outside experts as lecturers will be continued as it is an unqualified success but from time to time modifications will be introduced tending towards greater permanence as it would be unfair to expect high class men to continue year after year giving this work without compensation, especially when repetition becomes irksome. The lecturers' names and course during the past year are as follows: M.E. 68, Manufacturing Plant Design, Mr. Chas. Day, Mr. H. W. Wharton, Mr. H. Stimpson; M.E. 52, Works Management, Mr. Chas. B. Going, Mr. C. U. Carpenter, Mr. H. Emerson, Mr. J. N. Gunn, Mr. R. Lingley; M.E. 54, Principles of Machine Manufacture, Mr. F. Miller, Mr. E. Neff, Mr. C. E. Coolidge, Mr. G. N. Jeppson, Mr. C. Norton, Mr. D. B. Bullard, Mr. H. Aikman; M.E 66, Elevating & Conveying Machinery, Mr. L. DeG. Moss; M.E. 62, Refrigeration & Ice Making Machinery, Mr. F. Ophuls.

3. *Necessity for Better Teaching.* — In some cases during the past year the classes were abnormally large and far in excess of what seems to be proper for good teaching. For example, there were about 300 students taking the course in steam power machinery at one time and about 200 taking that on technical thermodynamics, a strictly mathematical subject. This difficulty has been removed in part for the coming year by the appointment of a new instructor, Mr. T. McC. Gunn, who will take the students in small sections for recitation, the lecturing to the large class continuing to conserve the time of the professor and still permit of the more experienced presentation of the subject. It seems proper that nearly all lecture work be eliminated as soon as possible. Changes that will be required to accomplish this will be: first, more instructors; second, better and new text-books. With regard to text-books: all the officers of instruction are now engaged in writing

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their lectures with the idea of revision for a few years in succession and then having the revised matter set up in type to constitute a proper text. This is quite necessary as the scope of the instruction now is beyond the available texts and it is believed to be a better plan to write books to fit a high instruction standard than to reduce the standard to that of existing books.

4. *Desirability of More Research.*— It is unfortunate that the amount of research work in the past year has fallen close to zero and this is a necessary consequence of excessive undergraduate instruction demands on the various members of the department. No department can hope to maintain a very high standard before the public, which does not produce research results of recognized high grade, and it is hoped the time will come when the schedule assignments can be lightened to such a point as to permit every man in the department to carry on such research as will lead to the publication of at least one good paper per year. In this connection it seems also important that the equipment of the laboratory so necessary for undergraduate instruction be also used by research students, possibly working under fellowship grants, so that the data-producing capacity of the department will be extended.

5. *Data Library.*— The development of the courses towards a proper concurrence with present day practice makes it quite essential that the department become the repository of large quantities of data in the form of published papers, transactions, catalogues, blue prints and photographs of machinery. Much of this material has been collected by correspondence and personal solicitation, but it cannot be properly filed for reference without special appropriation nor can it be used to best advantage by either students or instructors without the assistance of a library attendant. It will be necessary, therefore, before a great while to provide a room for the filing of such data and an attendant to file catalogues, loan and check off returns. It will also be necessary in this connection to have a fund from which papers can be bought, photographs, drawings and charts can be made or reproduced.

6. *Laboratory Space.* — The laboratory equipment during the past year has received practically no additions of importance but has been brought to a state of fairly good condition. Some of the machines still require repairs beyond what can be allowed from the annual appropriation and the whole laboratory should, for the securing of most efficient work, be expanded into greater space. It is hoped that before long, at least three times the floor space will be available for expanding the present equipment even without any addition to the apparatus and there are many important additions to the equipment necessary to round it out, room for which can be made in part by disposing of some of the parts of the present equipment which are in the nature of unnecessary duplicate or non-representative pieces.

7. *Directed Study Room.* — It has been found by investigation that many of the student complaints of overwork are traceable to waste of time and lack of coördination. A good deal of this waste of time on the part of the student comes from an attempt to do home work problems or write reports out of hours when the nature of the requirement is but indistinctly understood. To meet this need a table has been placed in

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one of the laboratories close to the instructor's desk and students have been encouraged to do their preliminary studying and report writing at this table between the hours of four and five, and in the case of laboratory reports to write as much as possible of the report during the progress of the test and immediately following its completion. Experience with this study table has proved it to be a necessary element in time conservation and it is believed that the provision of proper accommodations for a study room and the continued presence of an instructor in that room would at least double the capacity of the student in doing home work of problem, drafting or report nature.

8. *Shop Work.* — In the past the shop work instruction has not been satisfactory for students of mechanical engineering and it is believed that it can never be satisfactory and properly coördinated with the courses of this department to which it is essentially related, until the work is performed within the department and not by some other department. In every engineering school where a course in mechanical engineering is established shop work is part of the instruction of that department, whereas at Columbia it is given not only by another department but at such a distance as to render even inspection visits difficult. It will be quite necessary in time for the department to acquire its own shops and operate them in connection with laboratory repairs for not only this department but all departments of the university, as well as to serve as a demonstration of shop processes, methods, management, cost keeping and accounting.

9. *Summer Work.* — Summer work in shops, factories and power plants, required in the second and third years, has proved most valuable and will be continued, but for its most effective contribution to the students supervision is necessary, and it is hoped that a permanent understanding with some of the existing manufacturing plants and power plants in the vicinity of the city can be secured which will permit supervision of this practical work during the summer when the staff of the department has been increased sufficiently. When shop instruction has been incorporated into the department the instructor of shop work may properly be expected to supervise the practical summer work of his students in manufacturing establishments while the instructor in charge of power plant design, or his assistant, might be properly expected to supervise the summer work in operating power plants, assuming the compensation to be sufficient to pay for the full year's work. It is also believed that the present limit of six weeks in this summer work should be extended to a little over two months so as to give the students not more than one month's vacation, which seems to be sufficient.

10. *Printed Matter and Course Synopses.* — For the information of prospective students and the information of the public, the University should issue pamphlets describing each course and in far greater detail than is possible in catalogues. These synopses should also be distributed to students at the beginning of the course that they may follow the work more carefully and can be mailed to prospective students, on demands for more detailed information than the catalogues afford. It is surprising what a large amount of repetition correspondence must be carried on in an attempt to explain the nature of the work in any one

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of the courses and what a lot of time is spent in the office explaining to visitors the work of the entire department. Practically all of this can be saved by the printing of such circulars of information.

CHARLES E. LUCKE.

DEPARTMENT OF CHEMISTRY.

(Based on the Annual Report of the Head of Department, for the year 1908–1909.)

The Chemical Department is to be congratulated upon the establishment of the Samuel Anthony Goldschmidt Fellowship in Chemistry, which it owes to the generosity of Mr. George B. Goldschmidt, who has created this fellowship in perpetuity with an income of $650 a year. This fellowship is to be awarded under the same conditions as the university fellowships. The first incumbent is Mr. Edwin Calvin Kendall, who is conducting a most interesting and promising investigation under the direction of Professor Sherman upon the conditions determining the activity and power of amylolytic enzymes.

Samuel Anthony Goldschmidt was a member of the class of '71, receiving the degree of Engineer of Mines. He had previously received the degree of A.B. at the College of the City of New York and he subsequently received from Columbia the degrees of A.M. and Ph.D. in chemistry. In 1871 he was assistant on the Ohio Geological Survey; from 1871–75, assistant inspector of fertilizers, Savannah, Ga.; was also assistant to Professor Chandler; subsequently was inspector of offensive trades for the board of health and afterwards made an expedition to the Guano Islands of the South Pacific on an inspection tour. Since that time he has been President of the Columbia Chemical Works. It is a great satisfaction to the chemical department to have the name of so worthy a graduate perpetuated in so useful a manner.

The changes in the teaching staff during the past year were as follows:

Dr. V. J. Chambers, instructor in organic chemistry, resigned to accept the professorship of chemistry in the University of Rochester, and Dr. J. M. Nelson was appointed tutor in organic chemistry to succeed Dr. Chambers. Dr. Alfred Hoffman was appointed assistant in organic chemistry.

Charles H. Ellard, A.M., tutor in analytical chemistry (qualitative), resigned to accept a position in the chemical department of the Stuyvesant High School.

Dr. F. L. Jouard has served as assistant in electrochemistry and Mr. Dorris W. Whipple and Mr. C. W. McKone and Mr. E. M. Flint as assistants in analytical chemistry. Mr. Whipple having resigned during the year was succeeded by Mr. McKone.

With the close of the year (1908–09) Dr. J. S. C. Wells retired from the position of adjunct professor of analytical chemistry in charge of qualitative analysis, and the instruction in qualitative analysis was assigned to Dr. H. T. Beans, who will be assisted by two tutors and an assistant.

In spite of inadequate laboratory facilities, Chemistry A has been given this year to 82 students in the first half and 90 in the second half-year. The course will be lengthened next year to a year's course

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of lectures and recitations with a total credit of 8 points, laboratory facilities being provided by having the qualitative laboratory open for this work on Saturday mornings. Dr. Neish will be given an ample number of competent assistants to carry on this course during the coming year.

The attendance upon courses in chemistry in the summer school of 1908 was 292, which is 7.89 per cent. of the total enrolment of the summer session and an increase of 35 over the registration for chemistry in any previous summer session.

The details of attendance in the department of chemistry for the year 1908–09 are shown in the following table:

NUMBER OF DIFFERENT STUDENTS TAKING ONE OR MORE COURSES IN CHEMISTRY, 1908–1909.

Pure Science, A.M.	28	
Pure Science, Ph.D.	17	
Teachers College	10	
Extension Teaching	13	
		68
Applied Science, 1909	61	
" " 1910	82	
" " 1911	182	
" " 1912	202	
" " Specials	12	
		539
Columbia College, 1909	26	
" " 1910	72	
" " 1911	59	
" " 1912	125	
" " Specials	15	
		297
Total		904

The registration thus shows an increase of 105 men as compared with last year.

During the year Dr. Chandler has been one of the speakers at the dinners of the Early Eighties and also at the dinner given in honor of Professor Van Amringe and was chairman of the Schweitzer Celebration Committee, which held a banquet in honor of Dr. Hugo Schweitzer in March. He has also been the guest of honor at dinners of the Columbia Alumni Associations of Washington and of Buffalo.

Professor Pellew has given a series of public lectures on dyestuffs and dyeing under the auspices of the School of Fine Arts at Columbia, and has also lectured before the National Arts Club and the National Society of Craftsmen. On March 20, Professor Pellew lectured before the Cooper Union Chemical Society on "Modern Dyestuffs Applied to Ancient Dyeing Processes," and on March 25, at Pratt Institute, before the Handicrafters Club on "Batik or Wax Resist Dyeing." He has also written a series of papers for the *Craftsman* upon the application of modern dyestuffs in arts and crafts work. Professor Pellew and D. W. Whipple have secured U. S. Patent 884756 on a new process for the commercial manufacture of solid tetrachloride of tin.

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Professor Bogert completed during the year his second term as president of the American Chemical Society. During the two years of Professor Bogert's presidency of this national organization the Society gained over 1,000 members, a new journal (*Journal of Industrial and Engineering Chemistry*) was successfully launched and many important changes in policy and organization were carried out. Professor Bogert was by invitation a member of the Second Joint Conference on Conservation with the governors of the states and territories held at Washington, December 8–10, 1908. He is also a member of the American Advisory Committee of Honor of the Seventh International Congress of Applied Chemistry, which meets in London May 22 to June 2. On March 19, he addressed the American Philosophical Society at Philadelphia on "Coal-Tar Products and their Application in the Arts and Medicine." His presidential address on the "Function of Chemistry in the Conservation of Natural Resources" was printed in full in the *Journal of the American Chemical Society*, and in part in the last volume of this QUARTERLY.

Professor Morgan has continued during the past year his investigation on the weight of a falling drop of a liquid, and its relation to the other liquid constants, and is developing the process for making this important method available for general laboratory use as a means of determining critical temperature, molecular weight, etc. During the year three graduate students have registered with physical chemistry as a major subject, twelve others making it a minor subject for the degree of A.M. or Ph.D. The fourth edition of Professor Morgan's "Elements of Physical Chemistry" has appeared during the year.

This year Professor Tucker has directed the thesis work of the entire graduating class in the course in chemical engineering, all of the members of this class having selected electrochemistry as the branch in which to carry out their special investigations. The subjects assigned were arranged with a view to working out some problem in applied electrochemistry and projecting a complete plan to apply it to industrial work on a large scale. The third-year s udents in metallurgical engineering have been given a special course in electric furnace work with particular reference to iron and steel.

The laboratory for quantitatve analysis, which provides working facilities for 88 men, has been inadequate to accommodate the students in this branch of the department, so that it has been necessary to transfer many of the students who are working especially in organic analysis and food chemistry to the organic laboratory and during the second half-year Dr. Metzger was obliged to establish temporary working places in the electrolytic laboratory in order to accommodate all of the students in inorganic quantitative analysis. A large number of graduate students have been carrying on investigations both in the inorganic and organic branches of analytical chemistry and under Dr. Metzger's direction three students have completed their dissertations for the degree of Ph.D.

Dr. Metzger has served as accredited representative for entrance chemistry and has been reappointed to this position for the coming year.

Professor Sherman has served as a member of the Committee on Ad-

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missions for the Schools of Mines, Engineering and Chemistry and has been a member of the Executive Committee of the New York Section of the American Chemical Society.

In April, 1909, there was established at Columbia University the Gamma Chapter of the honorary chemical fraternity, Phi Lambda Upsilon. Membership in this society is limited to chemists and chemical engineers who are members of the faculty, graduates of the university, seniors or juniors who have entered the second half of the junior year with a sufficiently high rating as to scholarship and personality. The faculty members are Professors Chandler, Bogert, Morgan and Sherman. The president of the chapter is Mr. J. B. Barnitt; vice-president, Charles Crew; secretary and treasurer, Robert Schwarz.

The following contributions from the Havemeyer Laboratories were published during the year July, 1908, to June, 1909, inclusive:

VOLUME XI.

No. 152. The Weight of a Falling Drop and the Laws of Tate. The Determination of the Molecular Weights and Critical Temperatures of Liquids by the Aid of Drop Weights. II. By J. Livingston R. Morgan and Eric Higgins. *Journ. Am. Chem. Soc.*, *30*, 1055 (July, 1908); also *Ztschr. physik. Chem.*, *64*, 170 (1908).

No. 153. Some New Formulæ Correlating the Various Constants for Non-associated Liquids. By Eric Higgins. *Journ. Am. Chem. Soc.*, *30*, 1069 (July, 1908); also *Ztschr. physik. Chem.*, *64*, 298 (1908).

No. 154. 3-amino-o-Phthalic Acid and Some of its Derivatives. By Marston Taylor Bogert and Roemer Rex Renshaw. *Journ. Am. Chem. Soc.*, *30*, 1135 (July, 1908).

No. 155. The Effect of Pasteurization upon the Development of Ammonia in Milk. By W. G. Whitman and H. C. Sherman. *Journ. Am. Chem. Soc.*, *30*, 1288 (Aug., 1908).

No. 156. The Detection and Identification of Certain Reducing Sugars by Condensation with p. Brombenzyl-hydrazide. By E. C. Kendall and H. C. Sherman. *Journ. Am. Chem. Soc.*, *30*, 1451 (Sept., 1908).

No. 157. Chemical Evidence of Peptonization in Raw and Pasteurized Milk. By Rachel H. Colwell and H. C. Sherman. *Journ. Biol. Chem.*, *5*, 247 (Oct., 1908).

No. 158. The Calorific Power of Petroleum Oils and the Relation of Density to Calorific Power. By H. C. Sherman and A. H. Kropff. *Journ. Am. Chem. Soc.*, *30*, 1626 (Oct., 1908).

No. 159. A Comparison of the Calculated and Determined Viscosity Numbers (Engler) and Flashing and Burning Points in Oil Mixtures. By H. C. Sherman, T. T. Gray and H. A. Hammerschlag. *Journ. Ind. & Eng. Chem.*, *1*, 13 (Jan., 1909).

No. 160. The Calculation of the Critical Temperature of an Associated Liquid from Surface Tension Results. By J. Livingston R. Morgan. *Journ. Am. Chem. Soc.*, *31*, 309 (March, 1909); also *Ztschr. physik. Chem.*, *67*, 112 (1909).

No. 161. 3-amino-o-Phthalic Acid and Certain of its Derivatives. By M. T. Bogert and F. L. Jouard. *Journ. Amer. Chem. Soc.*, *31*, 483 (April, 1909).

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No. 162. Researches on Quinazolines (21st Paper): On Certain Quinazoline Oxygen Ethers of the Type -N:C(OR) and the Isomeric -NR.CO-compounds. By M. T. Bogert and C. E. May. *Journ. Am. Chem. Soc.*, *31*, 507 (April, 1909).

No. 163. A Rapid and Accurate Volumetric Method for the Determination of Cerium in the Presence of other Rare Earths. By F. J. Metzger. *Journ. Am. Chem. Soc.*, *31*, 523 (May, 1909).

No. 164. Preparation of Pure Cerium Salts and the Color of Cerium Oxide. By Arthur C. Neish. *Journ. Am. Chem. Soc.*, *31*, 517 (May, 1909).

No. 165. Does Thorium Exist as Thorium Silicate in Monazite? By Otto Kress and F. J. Metzger. *Journ. Am. Chem. Soc.*, *31*, 640 (June, 1909).

No. 166. The Condensation of Acetone by Means of Calcium Oxide. By Alfred Hoffmann. *Journ. Am. Chem. Soc.*, *31*, 722 (June, 1909).

C. F. C.

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BOOK REVIEWS.

Ore Dressing. By ROBERT H. RICHARDS. New York, McGraw-Hill Book Company, 1909. Vols. III. and IV. Large 8vo, xxv + 412 + 442 pp., 300 illustrations. Net $5.00 per volume.

Volumes one and two, 1,198 pp., appeared in 1903. The new volumes, three and four, now issued, constitute a supplement to the original treatise and cover the progress of the art during the past six years. Each chapter in the new volumes supplements, or corresponds with, chapters in the original book.

Volume three covers general principles, crushers, rolls, steam, pneumatic, spring and gravity stamps, miscellaneous pulverizers, laws of crushing, preliminary washers, sizing screens, principles of screen sizing, classifiers, laws of water classification, hand picking, jigs, laws of jigging, sand and slime concentrators, amalgamation, magnetic, electrostatic, pneumatic and flotation processes, samplers, feeders, conveyors, sand wheels and sand pumps, dewatering wheels and screens, dryers, cyanide machinery and weighing devices. Attached to each chapter is a bibliography as in the original volume.

Volume four contains descriptive outlines of ninety-four mills, some of which are included in the ninety-four mills of volume two, but are here given in revised form as the mills have been rearranged or remodeled since the original publication. Among the others are some old and a large number of the more important recent mills. The final chapter contains notes on power required for milling, water consumption, size limits of concentration, percentage extraction, cost of mining and milling and testing of ores and mill products.

The two new volumes contain a table of contents by chapters but no index. A complete index to the four volumes is promised in a fifth volume. The paper and press work of the new volumes are a distinct improvement over the early edition of volumes one and two.

The four volumes now constitute a complete encyclopedia on the art of ore dressing in this country. Those familiar with the original volumes do not need to be informed of the character of Professor Richards' great work. To others it will suffice to say that no better authority on this important subject has appeared in any language.

H. S. M.

Electro-Magnetic Ore Separation. By C. GODFREY GUNTHER. New York, Hill Publishing Co., 1909. Large 8vo, vi + 193 pp., 8 illustrations. $3.00 net.

This is an excellent treatise on a method of ore treatment of increasing importance written by an engineer having an intimate personal knowledge of the subject. In his preface the author states that "This book has been prepared to gather into convenient form published information on the magnetic separation of ores. The compilation has

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been made from the writer's observations and an extensive correspondence with mill engineers and manufacturers. It has been attempted to include only that which is at the present time of commercial importance."

The compilation has been well done, though, in some places, clearness has been sacrificed for brevity. The expert will find the data needed for his purpose but those without previous knowledge of the subject will, at times, find difficulty in following the author. This is especially true of chapters three and four, containing the description of magnetic separators. Perhaps it would have been well to have omitted many of the machines described and to have given additional space and more detailed description to the really important ones.

The introductory chapters on magnetism applied to ore dressing and on the essential elements in the design of magnetic separators, the testing of ores and the preliminary dry crushing and sizing of ores are brief but contain many suggestions of great practical value.

In chapter three, "separation of strongly magnetic minerals," will be found cuts and descriptions of thirty-three machines and in chapter four, "separation of feebly magnetic minerals," will be found descriptions and figures of thirteen machines belonging to this class. This descriptive matter covers 56 pages only, or an average of less than one and one fourth page, including cuts, for each machine described.

Chapters five, six, seven and eight, amounting to somewhat more than one half of the book, describes American and foreign practice in the treatment of different classes of ore to which magnetic separation is applicable. These chapters contain flow sheets and other data, from a large number of mills, and a summary of the results obtained. These mills are grouped under the following heads: concentration of magnetite, separation of pyrite and blende, separation of siderite from blende and separation of miscellaneous ores and minerals, including copper and iron sulphides, pyrrhotite, limonite, hematite, manganese oxides, franklinite, wolframite, monozite sands, leucite and other less important minerals. The chapter concludes with descriptions of the work of magnetic separation on tailings at Broken Hills, N. S. W.

H. S. M.

Timbering and Mining. A Treatise on Practical American Methods. By WILLIAM H. STORMS, E.M. New York, McGraw-Hill Book Company, 1909. Pages viii + 279. 125 ills. Price $2.00.

In 1892 the author of this book contributed Bulletin No. 2, on "Methods of Mine Timbering," to the publications of the State Mining Bureau of California. The present work is in part an expansion of the above named monograph, but contains also a large amount of matter relating to mining methods, with and without the use of timber throughout the workings. Its chief divisions are on: Preservation of Timbers, Drifting and Drift Sets, Driving in Running Ground, Structural Steel in Mine Workings, Shafts and Shaft Timbering, Cutting and Timbering Shaft Stations, Mining Large Ore-Bodies by the Open Cut Methods, Methods of Stoping, Raises, Caving Systems, Stoping in Swelling Ground, Stoping Large Ore-Bodies, Framing Square-Set Timbers, Mining at the Homestake Mine, South Dakota, and the Design of Head-Frames.

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The chapters on kinds of timbers commonly used and the modes of preservation are made up of statements contributed by several mine superintendents and operators, and from a pamphlet issued by the Government Forest Service. Drift timbering is treated mainly in the light of California practice and there is only scanty description and illustration of practice elsewhere. The same remark is true of driving in running ground. In view of the rapidly growing use of structural steel for the support of mine excavations, it will be thought that Mr. Storms has devoted too little attention to this practice (pages 34 to 37), which, though comparatively new in this country, has long been common in Europe. During the past few years, there have been placed on record a number of examples of the use of steel, especially for shaft linings, in Pennsylvania and the iron regions of the northwest.

One of the best parts of the book is that dealing with the timbering of shafts, particularly Chaps. IX. and X., on the framing and setting of shaft timbers. The chapters on Stoping in Swelling Ground, Stoping in Large Ore-Bodies and the application and methods of Framing of Square-Set Timbering, are also good. There are several interesting abstracts of papers on Stoping Wide Ore-Bodies by the block system, at the Broken Hill and the Central Mines, New South Wales, in Chap. XXIV., and Chap. XXV., on "Mining at the Homestake Mine, Lead, S. D.," is excellent.

The book closes with a chapter on the Design of Head-Frames, written by George S. Binckley, C.E., who published an article on this subject in the *Mining and Scientific Press*, June 10, 1905.

In the preface, the author states that "this work is not for the enlightenment of those who are experienced and therefore in no need of such a treatise, but rather for those who feel the need of a work which will give them practical ideas of what should be done under given conditions and how to do it."

R. P.

Rules for Recovering Coal Mines after Explosions and Fires. By W. E. GARFORTH, member Inst.C.E., F.G.S., Past Pres. Mining Assoc. of Great Britain. London, Colliery Guardian Co., Ltd.; New York, D. Van Nostrand Co. 71 pp., 3 folding plates. Price $1.50.

This little hand-book consists of three parts, namely: Suggested precautions to be taken *before* an accident, suggested rules for guidance *after* an accident, and a description relating to the recovery of the Altofts Pit.

In the first section the author deals with the measures which should be taken by the mine staff, ambulance stores, hoisting appliances to be used in the event of accident, electric lamps, ventilating plant, fire doors, special mine maps, printed instructions for workmen, rescue stations, training of rescue parties, rescue apparatus and its use.

The second section contains a set of numbered rules, grouped under the following heads: Persons and material to be sent for in case of accident, organization of exploration parties, use of portable breathing apparatus, rules for exploration parties, restoration of ventilation, treatment of survivors, pathological effects of carbon mon-oxide and di-oxide,

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handling of dead bodies, disinfectants, points to be noted for official inquiry and the restoration of underground roadways for resumption of work.

These two parts of the book, occupying 38 pages, are couched in plain, unmistakable language, and each rule is expressed with great brevity. The third part comprises an account of a serious explosion, which occurred some years ago in the well-known Silkstone Colliery, Yorkshire, England, where the depth of the workings was 1,260 feet, thickness of seam 3 ft. 6 in. to 3 ft. 10 in., and the daily product 1,000 tons. A detailed description of the workings is accompanied by several plates, and marginal references to many of the rules laid down illustrate their application and the results of their use in this particular case.

The book is substantially a reprint of papers contributed by the author to the First International Life Saving Congress, held at Frankfort, Germany, in 1908, and to the Institution of Mining Engineers, of England. It is addressed by an engineer to engineers and merits a careful reading by colliery superintendents and foremen.

R. P.

Hydroelectric Developments and Engineering. A practical and theoretical treatise on the development, design, construction, equipment and operation of hydroelectric transmission plants. By FRANK KOESTER, Consulting Engineer, Assoc. Member Am. Inst. E.E., Member Soc. German Engineers (Berlin), Author of "Steam-Electric Power Plants." New York, D. Van Nostrand Co., 1909. Pages xxv + 454; 500 ills. Price $5.00 net.

Part First of the treatise, on "The Transmission of Water Power into Electric Energy," occupies 260 pages, and is divided into seven chapters. Chapter I. deals briefly with the preliminary investigation of local conditions, forest preservation, the elements of hydraulics, measuring the flow of streams and general considerations as to the organization and work of the engineering staff. In the succeeding chapters are discussed at length the subjects of dams, flumes, tunnels, siphons, head-races, sluice gates, collecting basins and spillways; the design and construction of the buildings for housing the power plant, and the mechanical equipment, covering generators, switchboards, wiring, bus-bars, etc.

Part Second, on "The Transmission of High Tension Electrical Current," consists of three chapters, dealing respectively with transmission conductors, pole and tower construction, wooden and concrete poles, steel towers and insulators; general arrangement of substations, transformers, converters, motor-generators, frequency changers and substation switch-gear and lightning arresters. These subjects occupy 93 pages.

Part Third consists of detailed descriptions, with many illustrations, of eight important hydroelectric plants in the United States, Mexico, Norway, Germany, Italy and Austro-Hungary.

This work, dealing with a subject of great interest to engineers in all lines of professional work, is written by a man who is evidently well acquainted with both the principles and practice of this important

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branch of engineering. The plan of the book is excellent, the main features of the subjects being so grouped as to afford a clear, logical exposition of the whole; and the treatment is not too technical for those who lack a special training in electrical engineering. Numerous examples of existing plants are used to illustrate the varying modes of developing water powers in accordance with the local conditions, and of designing appropriate mechanical and electrical equipments. To each chapter is appended a good bibliography of books and articles in technical journals, for the use of those who desire further details.

In Chapter II. the elements of the theory of the design of dams are presented with sufficient fulness for the solution of all ordinary problems and are accompanied by many illustrations from practice. The treatment of the subject of head-races and penstocks, in Chapters III. and IV., is also good. The chapters on Power Plant contain a study of the arrangement, plan and construction, of the foundations of the plant and of the buildings in which it is housed, for low, medium and high head-water powers. A number of interesting examples are cited, taken from both America and Europe. Chapter VI. deals with the Mechanical Equipment, comprising the details of construction of turbines and impulse or bucket wheels, together with the different types of water governors. The modes of testing turbines are also outlined.

In Chapter VII., on the Electrical Equipment, the author properly omits the details of the design of electric generators, but gives a very satisfactory review of the different kinds of generators of the accepted types, with a full account of switchboards and accessory electrical apparatus. Chapters VIII., IX., and X., cover admirably the subject of high tension electrical transmission. Good tables are included, relating to the design of conductor lines, and there is an interesting discussion of their construction, with the use of wooden poles and of the more recent concrete or steel towers for important installations. A valuable feature of this chapter is the part dealing with the calculations for the towers and the determination of the most economical length of span. The chapters on substation plant and lightning arresters are excellent.

To the reader who is not a trained electrical engineer, the concluding section of the work will be found particularly interesting. The author has taken as examples a number of important hydroelectric plants, some of which, such as those in the vicinity of Niagara Falls, are among the largest and most elaborate in the world. They have been well selected to set forth the appropriate modes of dealing with varying natural conditions and are treated in considerable detail.

The typography of the book is good and the abundant illustrations are well executed, many of them being reductions of working drawings.

R. P.

Handbook of British Guiana. Edited and compiled by GEO. D. BAYLEY. Published under the authority of the Permanent Exhibitions Committee. Boston, J. H. Stark, 1909. 8vo, xxv + 607 pages. Price $1.20.

In this stout volume published at a nominal price the author, who is an officer of the British Guiana Civil Service sets forth, in behalf of the

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Permanent Exhibitions Committee, in attractive form and with many good illustrations a wealth of general and statistical information regarding the natural resources, development, government and commerce of the colony. It is said to be the first illustrated handbook which has been issued by British Guiana and seems well adapted to accomplish its purpose of bringing to the attention of capitalists and engineers the established industries of the country and the possibilities of development of its mining, forest, agricultural, and other resources.

The broad scope of the handbook may be seen from the following table of contents: Geography and Topography, 70 pages; History, 6 pages; General Geology, 13 pages; Climate and Hygiene, 2 pages; Meteorology, 9 pages; Population, 14 pages; Immigration, 12 pages; Constitution and Government, 33 pages; Education, 14 pages; Cities and Towns, 21 pages; Flora and Fauna, 25 pages; Financial, 6 pages; Agricultural Resources, 7 pages; The Mining Industry, 8 pages; The Crown Lands, 17 pages; Forests, 14 pages; Manufactures, 2 pages; Laws, Officers, Taxes, etc., 157 pages; Commerce, Transportation, etc., 113 pages; Mining Concessions, 5 pages; Corporate Bodies, etc., 23 pages; Statistics, 23 pages. It is stated that information supplementary to that contained in the handbook may be obtained upon application to the Permanent Exhibitions Committee of British Guiana, at Georgetown, Demerara.

H.C.S.

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U. OF M.

WILLIAM FELLOWES MORGAN

COLLEGE '80, MINES '84

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THE

SCHOOL OF MINES QUARTERLY.

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WILLIAM FELLOWES MORGAN.

At the convention of delegates from the various alumni associations of Columbia University held December 2, 1909, the choice for alumni trustee fell upon William Fellowes Morgan, '80 College, '84 Mines. Mr. Morgan thus becomes the second member of the chief authoritative body in the university to be elected by its graduates and to receive at their hands the principal office of trust within their gift. It would not seem possible to find a more broadly representative man for the office nor one better prepared by natural sympathies and experience to serve his alma mater.

Mr. Morgan was born at Clifton, Staten Island, on September 4, 1860, so that he is now forty-nine years of age. His father was David Pierce Morgan and his mother Caroline Fellowes Morgan. His preparation for college involved more experience than is usual with our entering students. He had been in attendance both at Rugby, England, and at St. Paul's School, Concord, N. H. His preparation was completed at Dr. Sach's School in New York. The fall of 1876 saw him registered in the class of 1880 and after the usual four years he was awarded his degree of A.B. A year of travel ensued and in 1881 he entered the School of Mines in the course in mining engineering and duly received his degree in 1884. Mr. Morgan is thus representative of both the College and the School of Mines.

All of Mr. Morgan's old-time contemporaries will remember that he not only maintained a high standing in the class-room but that he entered into the student life of his time and was universally

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esteemed by his associates. Fleet of foot by natural endowment, he most creditably represented Columbia on the track and in the other contests of the day. As captain of the foot-ball team he received this gratifying mark of confidence from his associates, and as president of the Intercollegiate Athletic Association, in the old days when Mott Haven was the scene of the annual meet, he became well-known far beyond the confines of Columbia.

Both while a student in the School of Mines and after graduation Mr. Morgan traveled extensively in the West, and was so fortunate as to make one transcontinental trip with Professor Newberry. He finally settled down in business in New York and became interested in the cold storage chambers which were established beneath the arches of the Brooklyn Bridge. He is now secretary and treasurer of the Brooklyn Bridge Freezing and Cold Storage Co., and is president of the Harrison Street Cold Storage Co. By means of these connections and by suitable indulgence in golf Mr. Morgan keeps himself in an excellent state of preservation, so much so that his old classmates can scarcely note any change in his appearance since we all sat together in the classroom of Professor Van Amringe in the early eighties.

Like many Columbia men, Mr. Morgan has served in the Seventh Regiment and only left the regiment to be a member of the staff of Brig. Gen. Wm. G. Ward. Mr. Morgan has made his home for more than twenty years at Short Hills, Essex Co., N. J., and here he has become active in many ways. For several years he has been president of the Board of Education of Millburn Township and has twice, 1906 and 1908, represented Essex County in the New Jersey Legislature. He has also been an active worker in the "New Idea" movement in the politics of New Jersey and as this uprising, though not always successful at the polls, has great force and many earnest men behind it, there is no doubt it will be an important factor in the state affairs in years to come.

Mr. Morgan has entered into the work of the Young Men's Christian Association, both at the university where he has been long a member of the Graduate Advisory Board, and downtown where he is president of the city organization. His activity in philanthropic work of this character has also led to his election as trustee of the Syrian Protestant College at Beirut.

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In the lighter affairs of life Mr. Morgan has cultivated golf and has for years been prominent in the affairs of the United States Golf Association of which he is at present treasurer. It has fallen to him to start the contestants in the tournaments and it has been his privilege to be one of the American committee which in association with the St. Andrew's Golf Club of Scotland has revised the rules for America.

In 1885 Mr. Morgan was married to Miss Emma Leavitt, and both from Mrs. Morgan and from the second of his three children he receives much valuable coaching in the ancient and honorable game just mentioned.

Despite his many business connections Mr. Morgan has kept in close touch with the affairs of Columbia. He has represented the Alumni Association of the Schools of Applied Science upon the Alumni Council and has been especially active in the affairs of his class. Last spring he was one of the Committee of '84 Mines which raised half of the $10,000 used in the improvement of South Field, and to his good work in connection with D. E. Moran and C. E. Pellew, the success of the effort is largely due.

It will readily appear from this brief outline that the newly elected trustee is a man of broad sympathies, of wide activities and of experience which well qualifies him to be of great usefulness as a member of the board. In no more influential and potential capacity can a graduate of Columbia serve his alma mater. Indeed the granting of the privilege of electing the six alumni members of the board has been one of the wisest and most far-reaching movements in later years. The graduates are brought within close and intimate official touch with the supreme governing body of the university. They can but feel that they have their own peculiar representatives and they have also the opportunity to honor with this mark of their confidence one who is specially the object of their regard. In this spirit alumni throughout the country extend their congratulations to William Fellowes Morgan, College '80, Mines '84.

J. F. KEMP.

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TAN BARK AS A BOILER FUEL.*

By DAVID MOFFAT MYERS, M.E.

It is the object of this paper to give the chief characteristics of wet spent tan as a boiler fuel. It is believed that tan bark contains a larger percentage of moisture than any of the other moist fuels. It is perhaps safe, therefore, to assume that its correct treatment as a fuel may indicate to a certain extent the most efficient means of dealing with other moist fuels.

The writer has been engaged in testing, remodeling, operating and constructing steam plants depending partly or principally upon tan bark for their fuel; and in connection with this work the following tests and observations were made, not only to determine the value of the fuel, but principally to indicate the most favorable conditions for its complete combustion and to improve the economy of the plants visited.

Physical Conditions.

The nature of tan bark is too well known to require minute description, but it may be stated, as relating directly to its use as a fuel, that its condition in the fireroom varies with the method of its preparation for leaching, and its treatment in the leaches. Bark which has been finely disintegrated and has been blown a long distance through a pipe or flue will reach the furnaces almost in the state of a wet powder, difficult to burn. On the other hand, with less thorough disintegration and a shorter fan drive, the tan will be in larger pieces which allow a freer passage to the draft. The tan in the fireroom varies in temperature according to its final treatment in the leach house and according to the distance it is conveyed from the leach to the furnaces. Under good conditions it often reaches the fireroom at a temperature of 110° F. The amount of moisture in the tan varies with the leaching process and usually runs from 62 to 70 per cent. Oak tan is easier to burn than hem-

* Presented at the annual meeting of The American Society of Mechanical Engineers, December, 1909.

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lock because it is harder and does not become soggy and pack on the grates, but admits the draft more freely than the hemlock.

Calorimeter Tests.

The calorific tests given in Table I. were made by Dr. Henry C. Sherman of Columbia University, the samples of tan being dried before burning.

TABLE I.

Calorific Values of Dried Spent Hemlock Tan.

Sample No.	B. t.u. per Pound.	Sample No.	B. t.u. per Pound.
1	9406	7	9519
2	9378	8	9450
3	9463	9	9504
4	9500	10	9850
5	9516	11	9472
6	9482	Average.....	9504

Samples 7, 8 and 9 each contained about 6 per cent. of oak tan.

Effects of Leaching.

Calorific tests were made to determine the effect of leaching on the fuel value of the tan, and it was found that the percentage of tannin left in the bark does not affect its calorific value per dry pound. As a check a further test was made, comparing a sample of leached bark and one of unleached bark. The result showed only a slight difference of heat units between the two and in fact a trifle more heat in the leached bark per dry pound. In other words it can be stated that the degree of leaching to which tan bark is subjected does not affect its fuel value, except inasmuch as actual weight is subtracted by the leaching process, so that a smaller quantity of fuel reaches the fireroom.

As regards the loss of weight due to leaching, 100 lb. of air-dry bark fed to the mill will produce 74.7 lb. of tan in the fireroom under good leaching conditions. This tan contains 65 per cent. moisture, *e. g.*, 100 lb. of air-dry bark ground at the mill result in about 213 lb. of spent tan, containing 65 per cent. moisture, in the fireroom; *i. e.*, the weight of the spent tan is 2.13 times the weight of the bark ground.

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Moisture.

Ten of these samples contained moisture varying from 63.6 per cent. to 68.27 per cent., the average moisture being 65.5 per cent. Many more moisture tests were made, but these ten samples are typical and represent about the average conditions in this respect. Taking the average calorific power of dried hemlock tan at 9,500 B.T.U., and the average moisture at 65 per cent., and calculating the loss due to moisture, we have: Loss by moisture $= 0.65\,[(212° - t) + 966 + 0.48\,(T - 212°)]$. For t we have the temperature of the moist fuel $= 100°$, and for T the temperature of the flue gases, which in tan burning averages about 500°. Substituting these values gives:

$$\text{Moisture loss} = 0.65\,(212 - 100) + 966 + 0.48(500 - 212)$$
$$= 660 \text{ B.T.U.}$$

Since a pound of fuel is 65 per cent. moisture, 0.35 lb., or the dry amount, must evaporate 0.65 lb. moisture. The calorific value of 0.35 lb. of dry tan is 0.35 of 9,500 B.T.U., or 3,325 B.T.U., which is the total B.T.U. in a pound of moist fuel. Subtracting the moisture loss we have 3,325 B.T.U. — 660 B.T.U. = 2,665 B.T.U., as the available heat in a pound of fuel as fired.

Tan Bark Compared to Coal.

As previously deduced, the weight of the bark as ground $\times$ 2.13 = the weight of the spent tan. Therefore the available heat for boiler purposes obtained from a pound of average air-dry hemlock bark is 2.13 $\times$ 2,665 B.T.U. = 5,676 B.T.U. As compared to coal of 13,500 B.T.U., 1 ton of hemlock bark ground at mill = 0.42 tons coal.

Chemical Analysis.

The chemical composition of dry tan is as follows:

	Per Cent.
Mineral ash	1.42
Hydrogen	6.04
Carbon	51.80
Oxygen	40.74
	100.00

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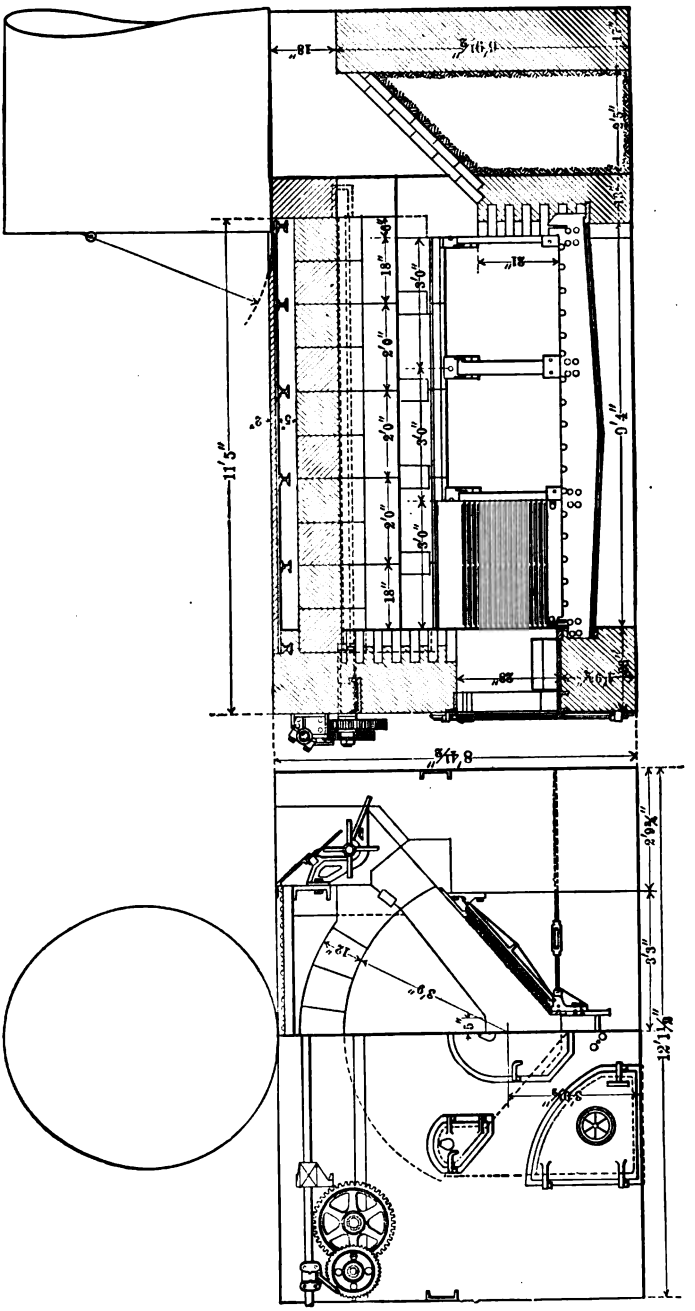

FIG. 1.

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This sample was hemlock tan containing 6 per cent. oak tan. When dried at 110° C., it lost 66.77 moisture.

Evaporative Tests.

The actual evaporative power of tan was taken from the results of 22 complete boiler tests burning tan alone. Eight of these were thermal-efficiency tests.

Four complete thermal-efficiency tests were also made using both tan and coal for fuel. The above tests were conducted in accordance with the Am. Soc. M. E. code, and in different parts

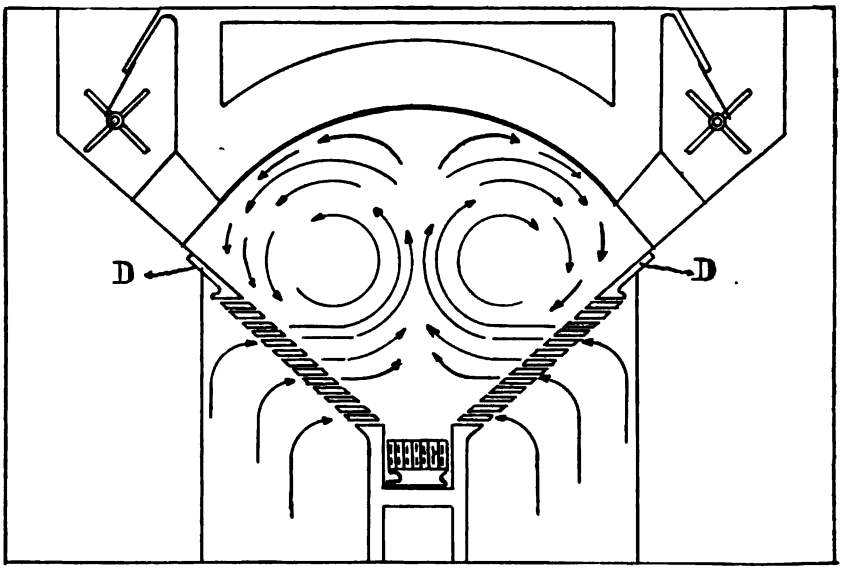

Fig. 2.

of the country, including the South, the East and the Middle West. The type of boiler in every case was the horizontal tubular. The furnaces varied considerably in design and economic results; but they were all of the Dutch oven type, set in front of the boiler; and all were fired from the top through feed-holes, with the exception of the furnace designed by the writer, the results and design of which will be described later. All the above tests were made under natural draft. Tables II. and III. show one of the 24-hr. boiler and furnace efficiency tests, selected to show what may be considered ordinary conditions and results in tan burning.

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By designing and constructing a special furnace for the purpose the writer obtained a thermal efficiency of furnace and boiler of 71.1 per cent., burning hemlock tan, efficiency based on available heat of fuel. The principal features of this furnace, which was

TABLE II.

BOILER TEST "X" TANNERY.

Data and Results of Evaporative Test on Boiler No. 6 to Determine Horsepower Developed and Efficiency of Existing Methods and Conditions for Burning Wet Spent Hemlock Tan as Fuel for Steam Generation.

Kind of fuel	Wet spent hemlock tan
Kind of furnace	Wide high oven, 2 rows firing eyes
Method of starting and stopping test	Alternate
Grate surface, square feet	92
Water heating surface, square feet	2089
Heating surface ÷ grate surface	22.7

Total Quantities.

Date of trial	November 5 and 6, 1902
Duration of trial, hours	24
Weight of tan as fired, pounds	53,000
Percentage of moisture in tan	65.6
Total weight of dry tan consumed, pounds	18,232
Total weight of water fed to boiler, pounds	69,825
Factor of evaporation	1.1216
Equivalent water evaporated into steam from and at 212 deg., pounds	78,316

Hourly Quantities.

Wet tan consumed per hr. pounds	2208
Dry tan consumed per hr., pounds	1823
Water evaporated per hr., pounds	2909
Equivalent evaporation per hr., from and at 212°, pounds	3263

Average Temperatures, Pressures, etc.

Steam pressure by gage, pounds	70.25
Temperature feed-water entering boiler	126.5
Temperature escaping gases from boiler	471
Force of draft between damper and boiler, inches water	0.39
Temperature outside air	64
Temperature of tan as fired	83

Horsepower.

Horsepower developed	94.6
Rated horsepower, at 15 sq. ft.	139
Percentage rated horsepower developed	68

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Economic Results.

Water evaporated under actual conditions per lb. tan as fired, pounds 1.32
Equivalent evaporation from and at 212° per lb. tan as fired, pounds 1.48
Equivalent evaporation from and at 212° per lb. dry tan, pounds 4.30

Efficiency.

Calorific power of dry tan per lb., British thermal units.. 9463
Percentage moisture in tan as fired..... 65.6
Available heat in 1 lb. of wet tan as fired, after subtracting loss due to evaporating moisture, British thermal units 2443
Efficiency of boiler including furnace, based on available heat in fuel, per cent..... 58.2
Efficiency of boiler including furnace, based on total heat in fuel, per cent..... 43.9

Firing.

2 rows of eyes, 3 eyes in each row. Eyes were fired according to regular method employed at this tannery, *i. e.*, they were refilled as they burned low, a large amount of tan being fired each time. 51 eyes were fired during the 24-hr. test.

subsequently installed in a number of plants, were: (*a*) Large combustion space over the burning fuel; (*b*) automatic stoking with rotating comb shafts; (*c*) oppositely inclined grate surfaces converging downward to a set of shaking and dumping grates; (*d*) drying on dead plates over which fuel passed before receiving air supply; (*e*) concentrated draft from opposing grate surfaces to a

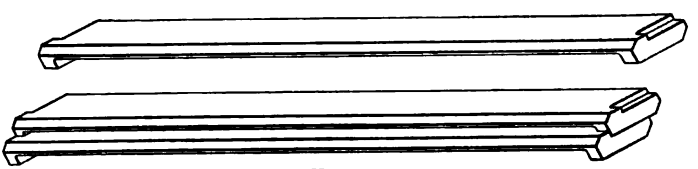

FIG. 3.

focus of combustion, caused by parallel spacing of longitudinal flat grate bars with beveled edges; (*f*) reverberating draft action resulting from concentrated draft-currents and the curvature of the arch, thus directing flames back upon dead plates. The full results of a test on this furnace are given in Table IV.

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This furnace is shown in Fig. 1 and the action of the special draft in Fig. 2. Fig. 3 shows the construction of the grate bars, which provide the horizontal draft opening tending to produce the draft action illustrated in Fig. 2.

Effect of Pressing and Burning Mixed with Coal.

It was desirable to learn the exact economic effect of burning coal with pressed tan and also the result of pressing the tan to eliminate some of the moisture. For these purposes three thermal-

TABLE III.

Flue-Gas Analysis.

Damper Wide Open.

No.	Time.	CO_2 Per Cent.	O Per Cent.	CO Per Cent.	Firing.
1	9 : 45	10.8	7.5	—	30 minutes after.
2	10 : 21	4.2	12.3	—	30 minutes after.
3	11 : 48	11.5	7.0	—	14 minutes after.
4	12 : 29	5.0	15.0	—	22 minutes after.
5	1 : 37	4.6	15.1	0.5	While firing.
6	2 : 06	5.0	13.0	0.3	14 minutes after.
7	3 : 05	9.2	—	—	40 minutes after.
8	4 : 08	9.8	8.4	—	While firing.
9	5 : 30	12.6	6.6	0.1	5 minutes after.
10	6 : 20	12.6	7.0	0.5	26 minutes after.
11	6 : 55	11.6	7.4	0.2	25 minutes after.
12	7 : 50	13.0	6.0	0.6	20 minutes after.
13	8 : 55	13.0	7.2	0.1	While firing.
14	10 : 09	11.0	9.1	—	6 minutes after.
15	11 : 07	12.5	6.9	0.1	29 minutes after.
16	12 : 23	11.5	7.5	0.8	23 minutes after.
17	1 : 07	7.6	11.8	1.1	67 minutes after.
18	2 : 10	12.5	7.7	0.0	24 minutes after.
19	2 : 50	6.0	13.5	—	20 minutes after.
20	4 : 00	4.3	15.7	—	58 minutes after.
21	5 : 30	3.0	16.4	0.3	While firing.
22	6 : 02	11.0	8.8	0.0	27 minutes after.
23	6 : 37	9.0	9.8	0.0	6 minutes after.
24	7 : 35	8.7	11.0	0.2	9 minutes after.
Average		9.2	8.2	0.32	

TABLE IV.

Boiler Test Automatic Stoker Furnace Designed by the Writer.

Data and Results of Evaporative Test on Boiler No. 1 to Determine Horse-power Developed, and Efficiency of Boiler with Automatic Tan Stoker.

Kind of fuel.....Wet spent hemlock tan
Kind of furnace.....Automatic Stoker

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Method of starting and stopping test.....Alternate
Grate surface, square feet.....61.5
Water heating surface, square feet.....1795

Total Quantities.

Date of trial.....August 14, 1903
Duration of trial, hours.....12
Weight of tan as fired, pounds.....18,600
Percentage moisture in tan.....65.3
Total weight of dry tan consumed, pounds.....6449
Total weight of water fed to boiler, pounds.....33,004
Factor of evaporation.....1.085
Equivalent water evaporated into steam from and at 212°, pounds.....35,809

Hourly Quantities.

Wet tan consumed per hr., pounds.....1550
Dry tan consumed per hr., pounds..... 537
Water evaporated per hr., pounds.....2750
Equivalent evaporation per hr. from and at 212°, pounds....2984

Average Temperatures, Pressures, etc.

Steam pressure by gage, pounds..... 43
Temperature feed-water entering boiler..... 155
Temperature inside furnace 1100
Temperature in combustion chamber.....1475
Temperature gases escaping from boiler..... 493
Temperature outside air 71
Temperature of air entering ash pit..... 78
Temperature of tan as fired..... 101
Force of draft between damper and boiler, inches water..... 0.4

Horse Power.

Horsepower developed 86.5
Rated horsepower of boiler at 15 sq. ft., per h.p.....120
Percentage rated horsepower developed.....72.1

Economic Results.

Water evaporated under actual conditions per lb. of tan as fired, pounds 1.77
Equivalent evaporation from and at 212° per lb. of tan as fired, pounds 1.93
Equivalent evaporation from and at 212° per lb. of dry tan, pounds 5.55

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Efficiency.

Calorific value of dry tan per lb., B.T.U.....9850
Percentage of moisture in tan as fired.....65.33
Available heat per lb. of tan as fired, B.T.U.....2623
Efficiency of boiler, including furnace, based on available heat in fuel, per cent.....71.1
Efficiency of boiler, including furnace, based on total heat in fuel, per cent.....54.4

Firing.

Firing was even and continuous with automatic stocking. Bed of fuel maintained on grates was about 9 in. thick.

TABLE V.

FLUE GAS ANALYSES.

Damper Open.

No.	Time.	CO_2 Per Cent.	O Per Cent.	CO Per Cent.
1	2 : 25	11	7.5	0
2	4 : 30	12.8	5.6	0
3	7 : 15	12	7.8	0
4	9 : 05	13	6.2	0
5	11 : 10	13	6.4	0
Average		12.4	6.7	0

TABLE VI.

ANALYSIS OF SPENT BARK.

Chemists' No. S.-736, Analyzed August 17, 1903.

	Per Cent.		Per cent.
Moisture	65.33	Non-tannins	2.35
Total solids	5.11	Available tannin	1.89
Total soluble solids	4.24	Reds	0.87

efficiency tests were conducted, all on the same boiler and furnace, the conditions as far as possible being the same in all tests, and the furnace operated by the same firemen. The furnaces and boiler were of the general type already referred to. The combustion chamber under the boiler differed by having a system of air admission through the bridge wall. The opening in the wall for admitting air to this system was set one fourth open in the first test and remained so in all three tests, each of ten hours' duration. An

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effort was made in each of the two tests without coal to equal the boiler output of the test in which coal was used; but as shown below this could not be done.

The furnace arch was equipped with two rows of firing-eyes of three eyes each, and two eyes on the same side of the furnace were usually fired at a time. The firing was heavy, the cone of tan nearly reaching the arch each time after firing. The furnace had a grate surface of 11 ft. 4 in. by 7 ft. 0 in. = 79.3 sq. ft., and the perpendicular distance from the grate surface to the highest point of the arch inside was 48 in. The boiler was 6 ft. by 18 ft. and

TABLE VII.

COMPARATIVE RESULTS OF THREE TESTS.

	Test No. 1.	Test No. 2.	Test No. 3.
Thermal efficiency of boiler including furnace, based on available heat in fuel, per cent	63.4	59.4	59
Evaporation from and at 212° per lb. tan as fired, pounds	1.98	1.90	1.65
Evaporation from and at 212° per lb. dry tan, pounds	5.43	4.71	4.54
Percentage rated h. p. developed	135.5	92.	72.4
Type of furnace		wide and high	
Heating surface ÷ grate surface	26.3	26.3	26.3
Number of firing-eyes	6	6	6
Depth of combustion chamber, inches	48	48	48
Kind of firing	deep	deep	deep
Firing intervals, minutes	18.8	18.8	19.4
Kind of fuel	pressed tan and coal	unpressed tan	unpressed tan
Moisture in tan, per cent	60.4	59.6	63.6
Steam pressure, pounds	76	74	63.4
Temperature feed-water	163	160	161
Flue temperature	561	486	445
Force of draft in uptake, inches water	0.51	0.49	0.43
Duration of trial, hours	10	10	10
Flue-gas analyses, averages per cent. CO_2	13.8	10.9	10.5
Per cent. O	4.9	7.8	8.6
Per cent. CO	0.15	0.93	0.68

contained 2,089 sq. ft. heating surface, the ratio of heating surface to grate surface being 26.3 to 1.

Nine flue-gas analyses were made during test No. 1, seven in each of the following tests, and the averages of these results are given in Table VII. which gives the most essential results of the three tests.

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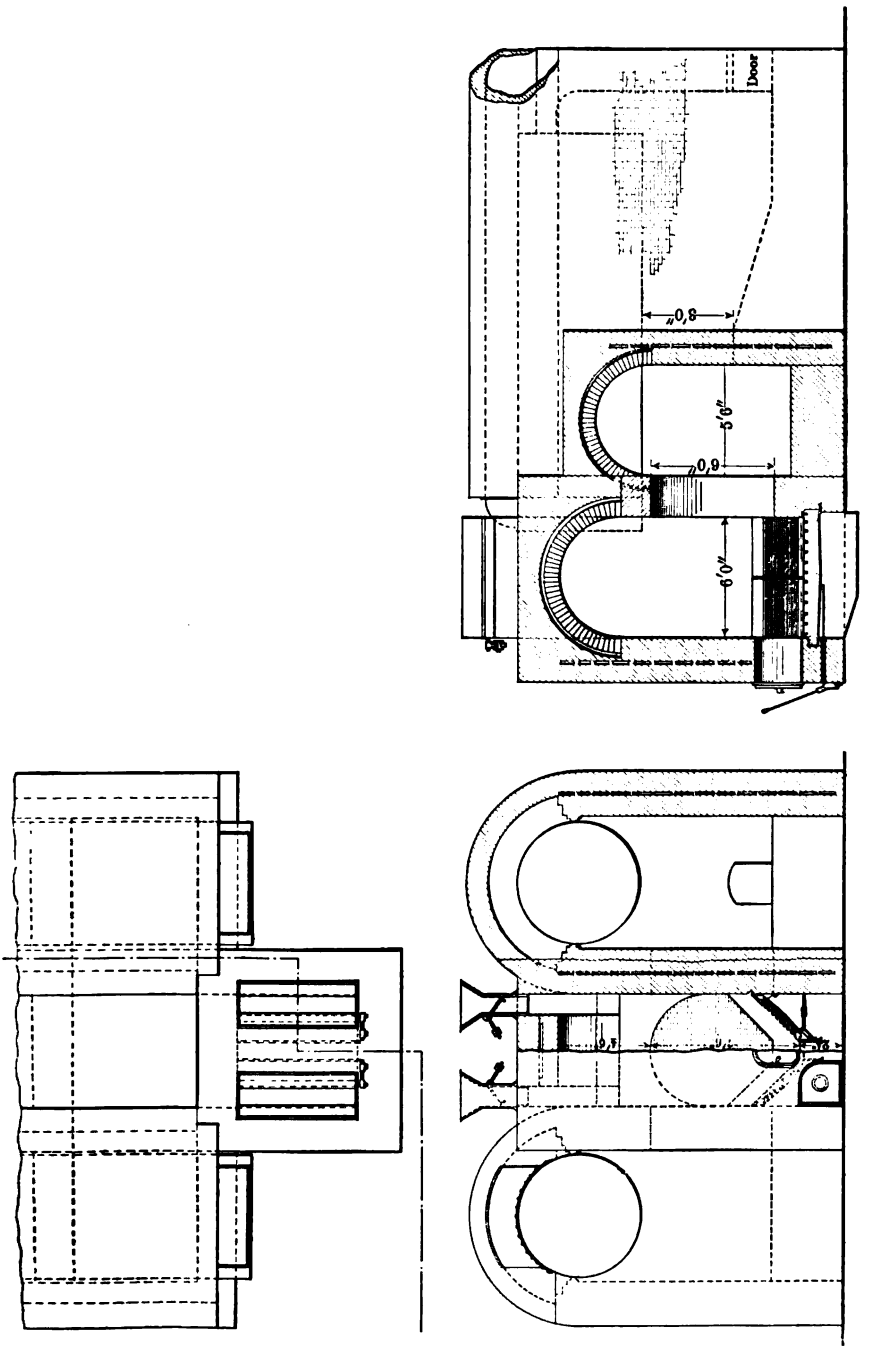

FIG. 4.

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The results of this series of tests show:

a That the burning of coal with pressed tan increased the thermal efficiency from 59.4 per cent. to 63.4 per cent.

b That the burning of coal with pressed tan increased the boiler output from 92 per cent. of rated capacity to 135.5 per cent. of rated capacity, the force of draft differing by only 0.02 in. water-gage.

c That the degree of combustion as indicated by the amount of CO_2 was raised from 10.9 per cent. CO_2 with pressed tan to 13.8 per cent. CO_2 with pressed tan and coal.

d That the flue temperature was increased from 445° with unpressed tan and 486 with pressed tan to 561° with pressed tan and coal.

e That the thermal efficiency based on available heat obtained with pressed tan was 59.4 per cent. as compared to 59 per cent. with unpressed tan.

f That the burning of pressed tan gave a boiler output of 92 per cent. rated capacity as compared to 72.4 per cent. with unpressed tan, the draft being only 0.04 in. water-gage stronger in the test of greater capacity.

g That since the thermal efficiency was practically the same with both pressed and unpressed tan the principal advantage of pressed over unpressed tan in this particular case lies in the intrinsically greater calorific value of the pressed tan owing to its reduced moisture. In this particular case, in which the unpressed tan contained 63.6 per cent. and the pressed tan 59.6 per cent. moisture, the actual gain in available heat-units was 4.5 per cent. over the unpressed tan or 1⅛ per cent. gain in heat value for each per cent. decrease in moisture.

Tan Presses.

Tan presses for reducing the moisture in actual practice result in a total economic gain of only about 7 per cent.; and against this must be charged the power to run them, maintenance, repairs and often the disadvantage of noise and vibration in the fireroom.

The question of installing a press must be determined principally by local conditions, such as amount of tan available, amount

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and proportion of coal used and its cost, intelligence of labor, average moisture in the tan as delivered to the fireroom, design of furnace and grate, cost of changing such design, etc. Especially when the firing is poor a press is of much value, for certain firemen who can get excellent steaming with pressed tan cannot raise steam with unpressed tan. When a press is introduced for tan burning and the moisture is reduced, the rate of combustion with given grate and draft is increased. Therefore to burn the pressed tan in the time required to burn the wet tan, it is necessary to reduce the grate surface proportionately.

For example, two complete 24-hr. evaporative tests were made on the same boiler and furnace, with the same firemen and with the same conditions as nearly as possible, the first with unpressed and the second with pressed tan, with the following results:

Test No. 1, without press, 64.4 per cent. moisture, consumption 14,565 lb. dry tan with 0.42 draft.

Test No. 2, with press 60.4 per cent. moisture, consumption 19.879 lb. dry tan with 0.38 draft.

Thus the rate of combustion on the same grate was increased 36.5 per cent. (It may here be noted that the boiler-horsepower developed in the first test was 89.3 h.p., and in the test with pressed tan 116.8 h.p.)

Therefore in this case to burn the tan in the same time as formerly it would be necessary to reduce the grate surface about 27 per cent. This is based on the above drop in moisture from 64.4 per cent. to 60.4 per cent., or 4 per cent. The drop in moisture with fair pressing will run between 6 and 7 per cent., representing a total gain of available heat of 7 to 8 per cent. With good pressing the grate surface may be properly reduced one third.

There have been cases of failure with pressing the tan simply because the precaution of reducing grate surface was not taken. Tannery superintendents have said, "We have tried presses and had to throw them out, because the tan would not last throughout the day, and we had to use more coal to make up the deficiency." The point here is that a tannery will almost invariably consume or waste every pound of steam its boilers will supply. With the press in operation the steaming was increased proportionately as long as the tan "lasted," no provision being made to correct the

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grate surface, and consequently the result would be exactly as stated by the superintendent. This has led to, or confirmed, the erroneous opinion held by some that the moisture in tan aids its combustion.

Effect of Small Combustion Space Over the Fire.

A special test on a low-arched furnace was made to obtain comparison with high arches. A furnace containing nine feed-holes, and having a height from arch to grate of 26 in., was tested, with the results shown in Table VIII.

TABLE VIII.

Results of Test on Low-Arched Furnace.*

Efficiency of boiler and grate, per cent	26.4
Evaporation from and at 212° per lb. tan as fired	0.63
Percentage rated h.p. developed	39
Heating surface ÷ grate surface	28
Depth combustion chamber under boiler	3′6″
Intervals between firing, minutes	6.3
Kind of tan	Hemlock
Percentage moisture in tan	67.2
Temperature flue-gases	422
Draft at damper, inches	0.37

These miserable results are to be attributed to the low arch and the consequently inadequate combustion-space between the fuel and the arch of the furnace. Owing to this small space the velocity of draft and gases was very high, thus removing the volatile fuel-gases from the furnace before their combustion could be fairly begun, and allowing no heating or mixing action in the furnace, and when they struck the boiler the combustion was checked or stopped.

The worst evaporative results ever obtained on various designs of higher furnaces, on tan alone and with poor firing are at least 100 per cent. better than this, and these other furnaces ran from 3 ft. 0 in. to 5 ft. and 6 ft. high; it is perhaps significant that the highest thermal efficiency was obtained in the furnace with the greatest amount of free combustion space between the fuel bed and the top of the arch.

* Average flue-gas analyses: CO_2, 4.3 per cent.; O, 11 per cent.; CO, 20 per cent.

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During recent years tanneries have been using more extracts and less bark for their liquors. At the same time a greater amount of machinery has been introduced and it has been found beneficial to use more heat in leaching. All these changes have resulted in greater steam requirements and less spent tan bark for its generation. Therefore more coal is required in the boiler room and stricter economy of fuel is necessary.

Burning a Mixture of Tan and Coal.

Among other methods of burning the two fuels, the ordinary coal-burning setting has been tried. The grates are usually of the shaking variety and are set directly under the boiler, and generally only 24 in. to 30 in. beneath the shell of the boiler. The coal and tan are fired alternately by hand. Owing to the large volume of tan as compared to its heating value (spent tan weighs about 33 lb. per cu. ft.) the fire doors have to be opened very often, thus admitting a great excess of cold air to the fire. The fire bed has a strong tendency to burn through in spots and form blowholes. The temperature-retaining effect of the Dutch oven arch is lost, and instead, the fuel gases come into direct contact with the shell of the boiler, which cools them before combustion is fairly under way. The result of every such case the writer has observed has been a dull, smoky fire of greatly varying temperature and never good combustion. In a certain plant where this method was thoroughly tried out, it proved so unsuccessful that it was discontinued and the grates were replaced by Dutch ovens in which the mixture of tan and coal was burned, the fuels being mixed before firing.

The above illustration affords a good comparison of combustion with and without a brick arch over the fire bed with hand firing, and goes to show that a brick or refractory arch is a necessity for good combustion, when the two fuels are so related in quantity that their heat values are about equal. As a further demonstration, experiments with automatic stoking may be cited. The mixed fuel was fed into a chain-grate stoker operating on induced draft. This was done under the most favorable conditions possible and under the supervision of an engineer representing the chain-grate company, with the assistance of the writer. The steam pressure and the furnace temperature dropped rapidly, and it was soon nec-

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essary to eliminate the tan and feed coal alone, to prevent the fire from going out. Experiment with different methods of mixing and feeding the two fuels all resulted in killing the fire.

Like experiments were conducted on a Detroit stoker set in front of boiler and having a brick arch completely over the fire. No scientific tests were conducted, but the mixed fuel easily carried the load formerly carried by the coal, it being necessary only to increase the speed of the stoker. The steam pressure was increased and as far as the eye could detect there was not the slightest decrease of furnace temperature, the combustion being clear and to all appearances excellent.

From these experiments it seems entirely safe to state that for efficient combustion of a mixture of tan and coal in ratio by weight of 5.2 to 1 a refractory arch over the greater part of the fire, and preferably over the entire fire-bed, is not only advisable but necessary. It follows that tan bark of the usual moisture and heat content cannot be burned without the application of a refractory arch, or some device of similar function, such as a large combustion chamber lined with refractory material.

Wood is sometimes burned in combination with tan in the same furnace. Good results are obtained when the wood is ground to about the same fineness as the tan, when it is known in the sawmill districts as "hog feed." When wood in slab or log form is burned in the same furnace with tan the results naturally are usually very poor, owing to blowholes formed in the fire bed and consequent large excess of air. A case of this description came under the writer's observation. "Edgings" from a nearby sawmill cost less than coal per 1,000 B.T.U., and it was the custom to fire the edgings by hand into the front fire doors of the tan furnaces, the tan being fired from above in the usual manner. A large amount of labor was required and the furnace fronts required constant repairing. By substituting coal for the wood in this case, and mixing with the tan before firing, a very good saving was effected in fuel, labor and repairs.

In regard to draft for tan burning, in 26 evaporative tests on tan-burning furnaces the average force of draft between boiler and damper was 0.45 in. water-gage.

The average draft, in 13 tests on tan where less than the rated

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capacity of the boiler was developed, was 0.42 water-gage between boiler and damper.

Draft and Grate Surface.

The average draft, in 12 tests on tan where rated capacity up to 60 per cent. over-capacity was developed, was 0.47 in. water-gage. This comparison is significant only in a very general way, owing to the great variety of ratios of heating to grate surfaces in the different tests, and the different methods and time intervals of firing. The highest force or draft found in any case between damper and boiler with chimney draft, furnaces burning tan only, was 0.63 in., and the lowest 0.32 in.

The lightest draft with which rated capacity was obtained was 0.32 in., and in this case the ratio of heating surface to grate surface was 21.8 to 1. In the test where 160 per cent. rated capacity was developed the force of draft was 0.51 in. and the ratio of heating surface to grate surface was 19.3 to 1. The greatest ratio of heating surface to grate surface which developed full rated capacity was 29.9 to 1, giving 110 per cent. rated capacity with force of draft in uptake 0.42 in. The firing in this case was excellent with intervals of 7.4 min.

TABLE IX.

Results of Nine Tan-Burning Tests.

Test No.	Tan.	Moisture, Per Cent.	Draft, Inches.	H. S. G. S.	Firing Intervals, Minutes.	B. H. P. per Sq. Ft. G. S.
1.....	Oak	0.53	0.63	29	15	2.35
2.....	Hemlock	.....	0.51	19.3	8	2.07
3.....	Oak	0.64	0.58	29	5	2.37
4.....	Oak	0.64	0.61	34.8	.....	1.53
5.....	Hemlock	0.65	0.61	17.4	50.8	0.92
6.....	Hemlock	.....	0.32	21.8	5.2	1.51
7.....	Hemlock	0.68	0.39	29.9	7.4	2.34
8.....	Hemlock	0.64	0.42	22.7	30	0.97
9.....	Hemlock	0 65	0.40	29.2	Continuous	1.31

Owing to space required, facility in cleaning fires, minimum radiation from furnace and expense of building and repairing, it is desirable to make the furnace grate area as small as possible and still conform to capacity requirements. It is therefore necessary to know the boiler-horsepower developed per square foot of grate

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surface. The force of draft, method of firing and ratio of heating surface to grate surface, are all factors in this result, also the moisture in the tan bark. Table IX. gives the most important factors with results of nine actual tests.

Inspection of this table shows that one factor above all the others influences the b.h.p. developed per square foot of grate, and this factor is the method of firing. Thus the tests in which the time intervals between firing are small show a marked increase in b.h.p. per square foot of grate. This test is upheld by many other tests of the writer. From the table we may take the following average results:

For oak tan with 60 per cent. moisture, 0.61 in. draft, in uptake of horizontal tubular boiler, and good firing of 15 min. or less between firing, 2.08 b.h.p. per sq. ft. of grate surface.

For hemlock tan with 65.5 per cent. moisture, 0.44 in. draft in uptake of horizontal tubular boiler, and good firing of say 17 min. or less between firing, 1.52 b.h.p. per sq. ft. of grate surface.

Grate Surface for Coal and Tan.

The above results are for burning tan alone. At the present time, however, it is very general practice, as previously set forth, to burn coal with the tan. The best results in most cases are obtained when the coal is mixed evenly with the tan, and the mixture burned in a Dutch oven with shaking and dumping grates. This practice modifies the boiler-horsepower per square foot of grate. The grate surface often allowed is at the rate of about 3¼ b.h.p. per sq. ft. of grate surface, the ratio of heating surface to grate surface ranging from 50 to 1 to 33 to 1.

Of course, as with tan alone, the development per square foot of grade depends upon the same factors, with the additional factors of the proportion of coal mixed with the tan, and the B.t.u. and character of the coal. The figures in Table X., selected at random, show the results in terms of b.h.p. per square foot of grate surface obtained in actual tests of burning coal with tan in Dutch ovens. It is of interest here to note that when the ratio of weight of coal to weight of tan as fired is 1 to 5.2, then the heat

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developed by each fuel is practically the same. This is figuring on 13,000 B.t.u. coal, and "tan as fired" containing 2,500 B.t.u. available heat, which is good average value.

TABLE X.

RESULTS OF TESTS OF BURNING COAL WITH TAN IN DUTCH OVENS.

Test.	Tan.	Grates.	Tan Moisture, Per Cent.	Uptake Draft.	H. S. G. S.	Firing Intervals, Minutes.	Weight of Coal to Weight of Tan as Fired.	B. H. P. per Sq. Ft. of Grate.
a	Hemlock	Shaking	68	0.40	33.5	20	1 to 8.9	2.52
b	Hemlock	Stationary	60.4	0.51	28.1	19	1 to 6.1	2.53
c	Hemlock	Stationary	66.7	0.67	37.3	6.3	1 to 46.4	2.70
**d*	Oak	Shaking	67.4	0.7	29.4	47	1 to 2.9	2.66
e	Hemlock	Stationary	66.5	1.05	32.8		1 to 22.8	1.33

In further reference to draft, a test which showed excellent results was made on a plant operating on induced fan draft. A small proportion of coal was used in the tan furnaces and a thermal efficiency of 66.1 per cent. was found under regular working conditions, the CO_2 in the flue gases averaging nearly 12 per cent. The writer has also observed an oak tan burning furnace operated temporarily on fan draft with closed ashpit. The combustion was apparently very good; a hot fire was maintained, but additional care was required to keep blow-holes from forming on the grates.

A reliable report has also been obtained on the installation of a steam-induced forced-draft system, applied under the grate of a tan-burning furnace. According to the report, the steam used for the draft condensed on the grate bars, with low temperature due to contact with the large mass of wet tan, and the concern that made the installation after considerable experimenting removed the appliance and gave up tan burning.

GRATES.

Grates for tan burning are made in different patterns, but usually contain from 20 per cent. to 30 per cent. air space, the actual opening between the bars being $\frac{3}{16}$ in. to $\frac{1}{4}$ in. Larger spaces than these allow the tan to fall through into the ashpit. A shaking grate is hardly necessary for burning tan alone, owing to the small

* Tubular Boiler, coal fired independently in front doors of double arched tan furnace. The 47-min. interval refers to the tan only.

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percentage of ash. No clinker is formed, only a very fragile crust on the grate obtains in three or four hours. In some cases fires are cleaned only once in 12 hrs. with good results. Unlike a coal fire, a tan fire should be shaken or disturbed very little. If a slice bar is used on a brightly burning tan fire, dense smoke results and the flame is killed for some time.

The temperature in the throat of a properly designed tan furnace, burning tan alone will reach 1500° F.

The depth of fuel on the grate varies with the design of the furnace and the method of firing. In ordinary practice the tops of the cones of tan directly beneath the firing eyes vary from 1 ft. to 5 ft. above the grate surface, while the depth of tan where the cones meet will be from 6 in. to 18 in., depending on the design and firing of the furnace.

When spent hemlock tan forms a cone from the conveyor-discharge on the fireroom floor it forms an angle of slide of about 55° to the horizontal. Inside a hot furnace, however, this angle is about 45°, and in laying out a tan furnace the latter angle is used in figuring the distribution of fuel on the grate. The angle of slide of tan on a sloping grate is 39° to 41°, and these angles were used in designing the automatic tan furnace referred to previously.

Among other experiments with this fuel the writer has made tests to compare results of double settings with single settings. By double setting is meant a setting so arranged that two furnaces

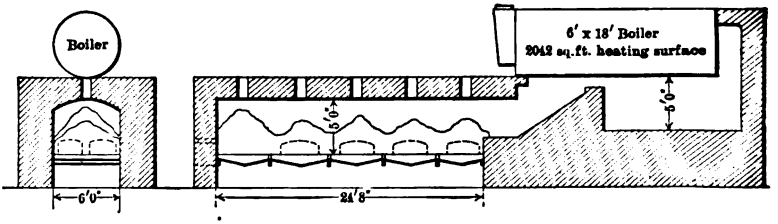

FIG. 5.

discharge their gases into a common combustion chamber beneath two or more boilers. Tests showed no tangible results in favor of either method as regards evaporation or fuel economy. It is possible however to imagine a case where the fire in a furnace

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might be in poor condition, when if the setting were a double one, the second furnace might maintain in the common combustion chamber a temperature sufficiently high to ignite and burn fuel gases discharged from the dull fire which otherwise would escape unburned. It is the opinion of the writer, however, that owing to the impossibility of laying off a single boiler for cleaning or repairs, a double setting is less desirable than a single setting. Furthermore, good firing and handling would in any case offset any possible advantage of the double setting.

The combustion of tan, as indicated by flue-gas analyses made with an Orsat apparatus, compares most favorably with the combustion of coal in factory plants where the same amount of atten-

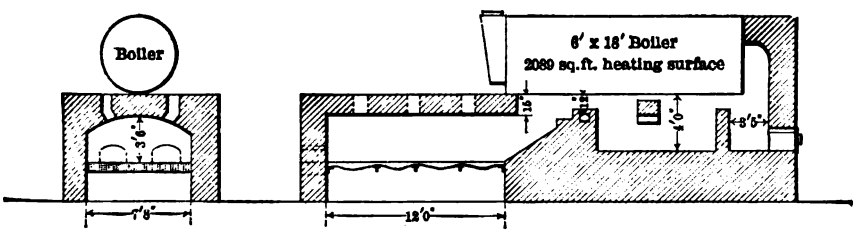

FIG. 6.

tion is paid to the boiler room. In fact, the percentage of CO_2 runs higher than in the ordinary coal-burning plant. For instance, the average CO_2 of 17 evaporative tests on different tan-burning furnaces was 11.3 per cent.; the lowest average CO_2 in any of the tests was 4.3 per cent., which represented unusually and abnormally poor conditions; and the highest average CO_2 in any one of them was 16.9 per cent. The CO averages about 0.5 to 0.6 per cent. and ranges from practically zero up to 2 per cent.

Fig. 9 shows graphically the relation of combined efficiency of boiler and furnace to CO_2 as determined from tests on tan bark.

The illustrations shown herewith are reproduced from working drawings and sketches and will give some idea of the construction of furnaces for burning spent tan bark, sawdust, and bagasse.

Figs. 5 and 6 show the types of tan furnaces found by the writer in common use throughout the country.

Fig. 5 shows what was known as the old Hoyt furnace. It was originally designed when tan bark was so plentiful that it was

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necessary to burn it to get it out of the way. The writer has found these furnaces with inside lengths as great as 24 feet on the grate surface.

Fig. 6 shows a more modern type of furnace designed to give a more even distribution of fuel on the grates.

Fig. 7 shows a more up-to-date furnace designed for the hand firing of a mixture of coal and tan, the coal being mixed with the tan before entering the furnace, which is supplied with shaking or shaking and dumping grates. When coal is mixed with tan in any considerable proportion more air is required for combustion,

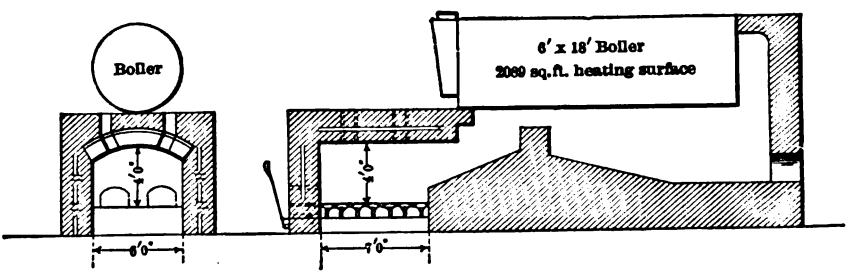

FIG. 7.

the best air spacing in the grate bar being found to be 3/8 inch. The percentage of draft area for this purpose should be about 40 to 50 per cent., depending upon how large a percentage of coal is used with the tan.

Fig. 8 shows a design of the writer's for an adjustable gravity feed furnace for burning tan or saw dust. The feed chutes are rectangular in section and contain adjustable chutes to regulate the depth of tan on the grates for any condition of draft, etc.

Prof. R. H. Thurston presented a paper on tan burning before the Franklin Institute in 1874. The results of two tests are recorded as 4.24 lbs. equivalent evaporation from and at 212 deg., in the boiler per lb. of combustible for the "Thompson" furnace and 3.19 lb. for the "Crockett" furnace.

Prof Thurston also records 5.68 and 4.41 for the Thompson and Crockett furnaces respectively. The writer finds upon examination of his test records that he obtained these latter figures by *adding to the evaporation in the boiler the amount of moisture in the fuel evaporated from and at 212 deg.*

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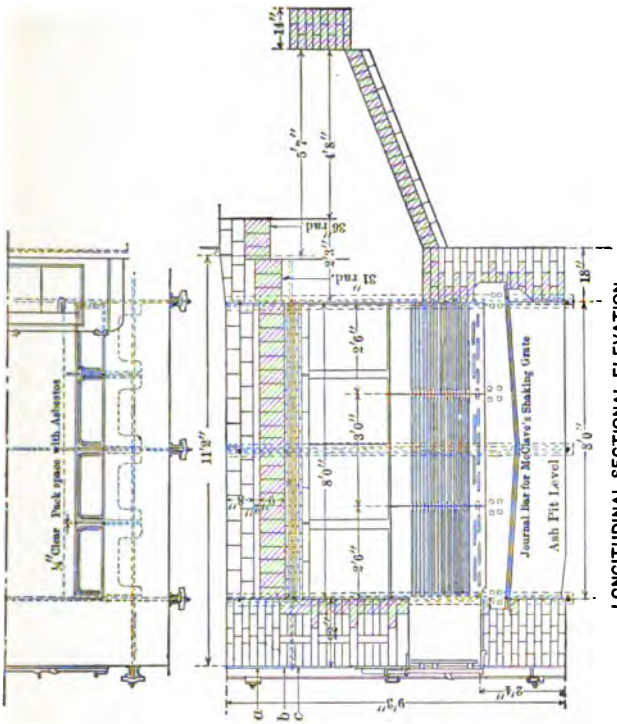
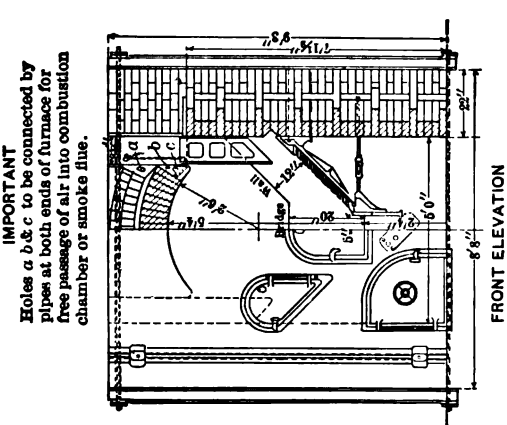


LONGITUDINAL SECTIONAL ELEVATION



FRONT ELEVATION

FIG. 8.

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A similar addition to the writer's best result with his automatic tan furnace would give 5.55 + 2.20 = 7.75 lb. including the moisture in the fuel. With the same basis of computation the results

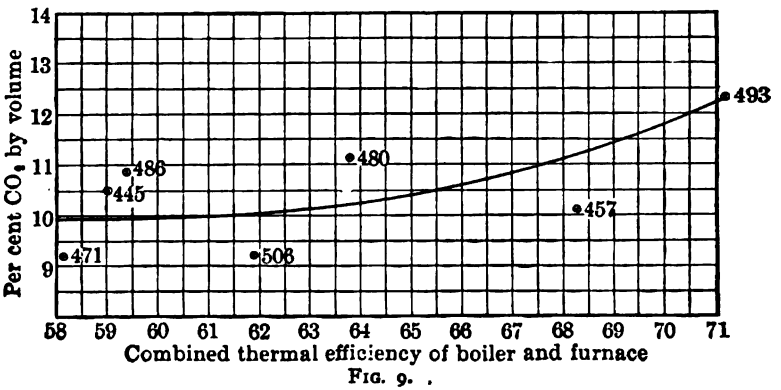

FIG. 9.

obtained in an ordinary tan furnace of the present time would give 6.63 lb.

These figures show a decided advance in the art of tan burning since 1874 which amount to an improvement of over 30 per cent. over the old furnaces.

SUMMARY.

The following statements concerning tan bark as a boiler fuel have been demonstrated by the foregoing data and confirmed by constant checking in actual practice:

Moisture.—In condition for firing, wet spent hemlock tan usually contains close to 65 per cent. of moisture.

Available B.t.u.—Bomb calorimeter tests on many samples of spent lemlock tan give an average value of about 9500 B.t.u. per lb., sample being dried before burning. The available heat per pound as fired, after subtracting moisture loss, is about 2665 B.t.u.

Ratio Weights.—Since the weight of the spent tan in the fire room is 2.13 times the weight of bark ground at the mill, 1 lb. of ground bark produces an available heat value of 5676 B.t.u. Hence, as compared to coal of 13,500 B.t.u., one ton of hemlock bark is equivalent to 0.42 ton coal.

Effect of Leaching on B.t.u.—The heat value of spent hemlock tan is not affected by the degree of leaching, except inasmuch as the actual weight is affected.

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Chemical Composition.—The chemical composition of hemlock tan (sample containing 6 per cent. of oak) was:

C = 51.8, H = 6.04, O = 40.74, Mineral ash = 1.42 per cent.

As a fuel analysis this is of interest as regards the small amount of ash and the large amount of oxygen.

Boiler Tests.—The actual operation of tan bark as a fuel is shown by complete boiler tests made under working conditions, records of which are given above.

Improved Efficiency.—A considerable improvement in efficiency was produced by a specially designed furnace providing automatic feeding, large combustion space over fuel and special draft admission.

Tan Presses.—The use of presses for reducing the moisture in the tan before firing may be good economy if the amount of tan compared to the amount of coal used is considerable, and providing the grate surface is properly reduced to meet the demands of the more rapid combustion. In practice the grate surface is sometimes reduced one third on the introduction of tan presses.

Under usual tan-burning conditions the total gain in available heat from the use of a press is about $1\frac{1}{8}$ per cent. for each per cent. drop of moisture content, and this drop rarely exceeds 7 per cent., *i. e.*, a reduction of moisture from say 65 to 58 per cent.

The writer is of the opinion that the combined boiler and furnace efficiency would naturally rise considerably when tan presses are used, owing to increased furnace temperature and better combustion, although as shown by Table VII. the thermal efficiency was raised only from 59 per cent. to 59.4 per cent., the moisture in the tan being 63.6 per cent. and 59.6 per cent. in the two tests respectively. This may be explained, at least partially, by the fact that the grate surface was not reduced for burning the pressed tan.

Addition of Coal.—As a result of special comparative tests, made under similar conditions on the same furnace and boiler, the addition of about one pound of coal to six of pressed tan increased the combined furnace and boiler thermal efficiency from 59.4 per cent. to 63.4 per cent. The addition of coal also resulted in raising the average CO_2 in the flue gases from 10.9 to 13.8 per cent. The percentage rated capacity of the boiler was increased from 92 per cent. (without coal) to 135.5 per cent. with coal.

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Although the above precise statements were obtained from a single pair of accurate tests, the writer's subsequent experiences in many plants confirm the results as generally typical; and it may be safely stated that under usual working conditions the addition of coal to tan produces a decided increase in degree of combustion and a consequent rise of thermal efficiency. The increase of boiler output attending the use of coal with tan is also a factor of economy not to be disregarded.

Ample Combustion Space.—One of the most important factors, in designing furnaces for tan-burning, is that of ample combustion space. In usual tan-burning practice this means a high arch over the furnace. Low-arched furnaces are conducive to bad combustion, whereas furnaces providing an arch at a considerable height above the fuel on the grates give decidedly better combustion and higher efficiency. (See tests and discussion, par. 23 *et seq.*)

Refractory Arch.—A refractory arch or similar combustion arrangement is necessary for the economic combusion of tan. Tan in its usual condition cannot be burned in a common coal-burning setting without an arch separating the fire from the cooling surface of the boiler shell or tubes. Even when tan is enriched with coal to a point where the two fuels form equal heating values (about 1 lb. coal to 5.2 lb. wet spent tan) good combustion cannot be obtained in an ordinary coal setting. This holds true both for hand-firing and automatic stoking. (See tests and discussion, par 27 *et seq.*)

Draft.—The force of draft required in general practice for tan burning is somewhat higher than that required for producing the same boiler output with bituminous coal. No definite figures can be given for force of draft as related to tan burned per square foot of grate surface, owing to the widely varying designs of furnaces and methods of firing. It may be stated, however, that for full capacity not less than ½-in. draft should be provided for in the uptake of a horizontal tubular boiler, when the boiler is set so that the gases flow under the shell and through the tubes directly to the stack or breechen.

Horsepower per Square Foot of Grate.—The boiler-horsepower obtainable per square foot of grate surface, depending upon the rate of combustion of the tan, is an extremely variable quantity,

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but averaging the results of nine typical boiler tests it may be said that under usual conditions for oak tan the boiler-horsepower per square foot of grate is about 2.08; and for hemlock tan, 1.5 boiler-horsepower per square foot of grate is an average figure. As demonstrated by results of tests given in Table IX., the one factor which above all others influences the boiler output per square foot of grate is the method and comparative excellence of the firing, very short firing-intervals producing the higher output results.

Horsepower with Coal and Tan.—When coal is burned in the same furnace with the tan the development per square foot of grate varies of course with the richness of the mixture and with the other usual conditions, and it is best in designing furnaces for any particular plant to use the results of tests made under similar conditions. In four cases out of five selected at random the boiler-horsepower per square foot of grate was 2.5 to 2.7.

Draft Area and Air Spacing.—Grates for tan burning provide 20 to 30 per cent. draft area and the spacing is from $\frac{3}{16}$ in. to $\frac{1}{4}$ in.

Clinker and Ash.—Tan forms no hard clinker, only a light fragile crust, and a very small amount of ash (less than $1\frac{1}{2}$ per cent. based on dry matter), and a shaking grate is unnecessary except when coal is fired with the tan.

Furnace Temperature.—Excellent combustion of tan has given a temperature of 1500° F., in the throat of the furnace.

Single vs. Double Setting.—As a result of comparative tests made on single vs. double settings for tan burning, the writer believes that the single setting should have the decided preference. A possible though not a decided improvement in combustion is sometimes obtainable with the double setting, but this is more than offset, especially in the small plant, by the advantages of convenience for cleaning, repairs and adaptation to load given by the single setting.

Use of Wood with Tan.—When wood is used as a supplementary fuel to tan and fired in the same furnace, the best results are obtained by first grinding the wood to the size known as "hog feed." The firing of wood in log or slab form is disastrous both to the furnaces and to combustion.

Flue Gas Analyses.—Basing comparison on flue gas analyses, tan burns with a higher combustion than coal, under equally favorable

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conditions. The large amount of moisture in the tan produces a comparatively low furnace temperature, even with good chemical combustion, and acts against an equally high combined efficiency of furnace and boiler.

The highest thermal-efficiency test obtained gave 71.1 per cent. efficiency (on boiler and furnace, based on available heat in tan), and flue-gas analyses during this test averaged 12.4 per cent. CO_2. The approximate relation of CO_2 to efficiency as obtained under actual running conditions is shown by the curve, Fig. 1, which was plotted from seven thermal efficiency tests made on various designs of furnaces burning tan alone. The figure given at each point plotted is the temperature of the escaping gases during the test.

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SOME RECENT CONSIDERATIONS OF STRESSES IN HIGH MASONRY DAMS.

By CHARLES E. MORRISON.

Considerable discussion has been raised within the past few years by criticisms being levelled at the present general procedure in the design of high masonry dams. This has properly perhaps, been more pronounced abroad than in this country, since the matter may be said to have been precipitated by the publication of a paper by Mr. L. W. Atcherley, of London University, "On Some Disregarded Points in the Stability of Masonry Dams."*

It is the purpose of the present article to outline the analysis as presented there, and to call attention to some of the discussion which followed, in order to indicate the status of the theory involved in the design of such structures.

The paper referred to takes exception to current practice in regard to the matter of design and indicates a need for both revision and extension in the analysis; and then, supplementing the generally accepted notion in regard to the distribution of normal stress on horizontal planes, by an assumption as to the shear on these planes, proceeds to show that peculiar and unsuspected conditions arise.

It is a fact that, owing 1st to the manner in which masonry structures are built, *i. e.*, of a mixture of stone and cement, and 2nd to the nature of the sections at the springings or areas of support, it is practically impossible to apply to them the general theory of elastic bodies. Consequently, the treatment as it is employed to-day has been developed, but only by the use of certain assumptions which it may be shown are not precisely exact.

The basis of Atcherley's investigation rests upon the four following formulæ in which the usual distribution of normal unit

* Department of Applied Mathematics, University College, University of London. Draper's Company Research Memoirs. Technical Series, II.

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stress on horizontal planes is accepted, but to which is added an assumed condition as to the distribution of horizontal shear.

$$cd = \frac{1\zeta^2}{12} \tag{1}$$

$$C_{max} = \frac{Q}{A}\left(1 + \frac{6c}{\zeta}\right) \tag{2}$$

$$T_{max} = \frac{A}{Q}\left(\frac{6c}{\zeta} - 1\right) \tag{3}$$

$$S = \frac{3}{2}\frac{P}{A}\left(1 - \frac{4y^2}{\zeta}\right) \tag{4}$$

c = distance along the horizontal joint from the centroid to the point of application of the resultant.

d = distance along the horizontal joint from the centroid to the point locating the neutral axis.

ζ = length of the horizontal joint.

C_{max} = maximum compressive stress on the joint.

T_{max} = maximum tensile stress on the joint.

Q = vertical component of the resultant force acting on the joint.

A = area of the joint.

S = shear at any point y in the joint.

P = total shear on the joint.

y = the distance from the centroid to any point on the joint.

With regard to equation (4) it may be stated that it has not heretofore been customary to consider the distribution of shearing stress on horizontal joints. But if the distribution of normal stresses may be assumed to be represented by equations (1), (2) and (3), the author believes with equal validity for the usual types of dam may the shear at any point be assumed to be represented by equation (4). It is believed also, that these equations more nearly express the conditions of equilibrium in a dam than the usual ones do, even though the latter tacitly assume the first three by imposing the condition of the middle third, and use a friction condition instead of one for shear as expressed by equation (4). In reference to this friction factor there may be some question of doubt since, according to Atcherley, M. Lévy prescribes an angle of 30° for masonry on masonry, while Rankine gives 36°; on

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the other hand, examination of dams now doing service frequently shows the angle to lie somewhere between the above values.

But whatever its exact value, this friction condition leaves some question as to the actual distribution of shear over a horizontal joint, the variation of which must be known in order to determine the tensile and compressive stresses on *the vertical sections of the tail* (*i. e., down stream portion*) *of the dam.* In consequence of this the parabolic law as expressed by equation (4) has been assumed by the author and will later be shown to be more nearly correct than any other hypothesis.

According to the author there is no reason whatever why dams should be tested solely by taking horizontal cross-sections, and insisting that the line of resistance must lie in the middle third here, while the stresses across the vertical sections of the tail are ignored. If the former condition is valid, then no dam ought to be passed unless it can be shown also that there is no tension of any serious value across vertical cross-sections of the tail paralleled to the length. It is believed that a considerable number of dams as now designed will be found to have tension in these sections, and this in the opinion of the author is a source of weakness which has not been properly considered and allowed for.

If the problem is to be solved on the assumption that a dam is "isotropic and homogeneous," the general equations for stress can only be determined from the consideration that "(*a*) The normal and shearing stresses on the horizontal top and curved flank, *i. e.*, down stream face, are both zero; (*b*) the normal stress on the battered front or up stream face is equal to the water pressure, and the shear is zero, and (*c*) either the stresses or the 'shifts' must be supposed given over the base."

It follows from this that equations (1), (2) and (3) are not *absolutely* true, but that the shear is fairly closely represented by equation (4).

"As far as the present investigation is concerned, the enquiry is not as to the validity of the usual treatment; it is obviously faulty. But it is the purpose to try to indicate that, supposing it to be correct, its present *partial* application, *i. e.*, to horizontal joints only, involves the serious, and, it is believed, often dangerous, neglect of large tensions across the vertical sections."

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To justify the above statement, two model dams of wood were employed for experimental purposes, the cross-sections being identical, and agreeing with that of a dam actually constructed. One of these models was subdivided into horizontal strata to study the effect on such planes and the other into vertical longitudinal strata, for a similar purpose. The application of the loading was such that it approximated as closely as possible to the conditions obtaining in an actual dam. The general conclusions from these experiments follow:

"(*a*) The current idea that the critical sections of a dam are the horizontal ones is entirely erroneous. A dam collapses first by the tension on the vertical sections of the tail.

"(*b*) The shearing of the vertical sections over each other follows immediately on this opening up by tension.

"(*c*) It is probable that the shear on the horizontal sections is also a far more important matter than is usually supposed."

"We propose therefore to lay it down as a rule for the construction of future dams that the stability of the dam from the standpoint of the vertical sections must be considered in the *first* place. If this be satisfactory, we believe that the horizontal sections will be found to be stable, but of course the latter must be independently investigated."

The above conclusions were apparently verified by a combined analytical and graphical treatment in which the algebraical analysis will here be considered first.

Denoting the total vertical force acting on a horizontal joint by Q_0, and the total horizontal force acting over the same by P_0, under the assumption that the reservoir is full, the variation of the normal pressure on the joint may be represented by the straight line of Eq. (1).

If the resultant pressure on the joint be assumed to cut it at the extremity of the middle third, then according to the previous notation d will have a value of $\frac{h^2}{2c}$, provided $2b$ is the length of the joint. This indicates that the line representing the variation of normal pressure over the joint intersects it at the upstream edge, and any vertical between it and the joint itself will represent the normal pressure at that point where the vertical is erected. Denot-

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ing this by y, it may be termed "the vertical height-giving pressure," and may also be expressed in terms of height of masonry, if the factors upon which it depends are expressed in cubic feet of masonry.

Again we may write an equation of the down stream face, with respect to the same joint, so long as that face is a straight line, by making $y = mx$.

Evidently then if this latter line, and the one indicating the variation of pressure over the base, be referred to the same origin, the difference in areas included between each and the base will represent the total upward force, in cubic feet of masonry, acting over any assumed portion, "x" of the joint, measured from the origin.

Representing this upward force by F_1, its point of application may be determined, while the shear may be written as F_2, being regulated by Eq. (4).

As F_1 and F_2 thus give the total external forces, considering a wedge-shaped piece of dam bounded by the down stream face, a vertical and a horizontal plane, the total shear on the vertical plane must equal F_1 and the total thrust F_2, since these internal stresses are held in equilibrium by external forces. Thus F_1 now equals the total shear on the vertical section, at a distance x from the down-stream edge, while F_2 represents the total horizontal thrust over the same.

If y be expressed in terms of x, and locate the point on the successive vertical planes through which the resultant acts, then the equation will represent the line of resistance on these vertical planes. This is found by the author to be an hyperbola.

Considering the stresses on the vertical sections, it is found further: (1) that the maximum shear may be properly represented by 3/2, the mean value, and may be so arranged as to be expressed in terms of F_1 and mx. Such an equation, representing a straight line shows the necessity of thickening the down-stream portion which, as a matter of fact, is the usual procedure; (2) the line representing the maximum tensile stress may be shown to vary as a parabola whose axis is vertical.

When the down stream face ceases to be linear, it becomes necessary to apply a graphical solution for the determination of the

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stresses. This it is unnecessary to reproduce here, but the curves may be said to indicate the following results:

"1. That the line of resistance for the vertical sections lies outside the middle third for rather more than half the vertical sections. In other words, these sections are subjected to tension.

"2. That the tensile stresses in the tail are, for masonry, very serious, amounting to nearly 10 tons per square foot at the extreme tip, and to 6 tons per square foot after we have passed the vertical section, where the strengthening of the tail has ceased.

"3. That the maximum shearing stresses amount to 6 tons per square foot at the tip of the tail and 5 tons per square foot after we have passed the vertical section, where the strengthening of the tail has ceased. We lay no stress on the actual values of these 'maximum' shears on the vertical sections, as they are obtained from the mean shears by using the round multiplier 1.5. This round number is assumed because the maximum is certainly greater than the mean shear. The actual distribution of shear on the vertical sections has not been discussed. It would of course be found from that on the horizontal sections, if the latter were really known with sufficient accuracy, by the equality of the shears in two planes at right angles. We content ourselves, however, by showing that the *mean* shears on the vertical sections appear to be higher than those on the horizontal section, and thus indicate that the parabolic distribution applied to sections some way above the base, probably *under-estimates* the maximum shearing stresses in the dam."

In other words: *However we judge, the vertical sections seem to be the critical ones in a far higher degree than the horizontal sections.*

In a well-designed dam, the conditions for stability may have been satisfied for the horizontal sections, yet if applied to the vertical sections not one of them will be found to be satisfied. It seems therefore, unsatisfactory that the current tests for stability should be applied to the horizontal instead of to the far more critical vertical sections. In the case of the latter they fail completely; and if high tension and shear are to be allowed in the vertical sections, then they ought not to be excluded in the case of the horizontal sections.

Nor are these theoretical results unverified by experiment;

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they are absolutely in accord with the experiments on the model dams. These collapsed as might have been expected from the above investigation, *i. e.*, the dam with vertical sections gave before the dam with horizontal sections. The former collapsed by opening up of the joints by tension towards the toe, followed almost immediately by a shear of the whole structure. In the case of the horizontally stratified dam, the collapse occurred later and was due to shear of the base followed by a shear of one or more of the horizontal sections."

The question then arises as to how far the previously assumed distribution of shear affects the main features of the results, and so the other extreme is taken, *i. e.*, uniform shear, and the effect determined.

"This distribution must be further from the actual than the first hypothesis, yet we still find:

"1. That the line of resistance falls well outside the middle third for about half the dam.

"2. That there exist considerable tensions, 3 to 4 tons per square foot, in the masonry.

"3. That the average shearing stresses on the vertical sections are greater than on the horizontal sections. As a result of this extreme case, it is believed that the real distribution of shear over the base, whatever it may be, must lead us to a line of resistance lying well outside the middle third, and to tensions amounting to something between 5 and 10 tons per square foot."

From these investigations the following general conclusions may be said to result:

"1. The current theory of the stability of dams is both theoretically and experimentally erroneous, because (*a*) Theory shows that the vertical and not the horizontal sections are the critical sections; (*b*) experiment shows that a dam first gives by tension of the vertical sections near the tail.

"2. An accepted form of cross-section is shown to be stable as far as the horizontal sections are concerned, but unstable by applying the same conditions of stability to the vertical sections.

"3. The distribution of shear over the base must be more nearly parabolic than uniform, but as no reversal of our statements follows when we pass from the former to the latter extreme hypoth-

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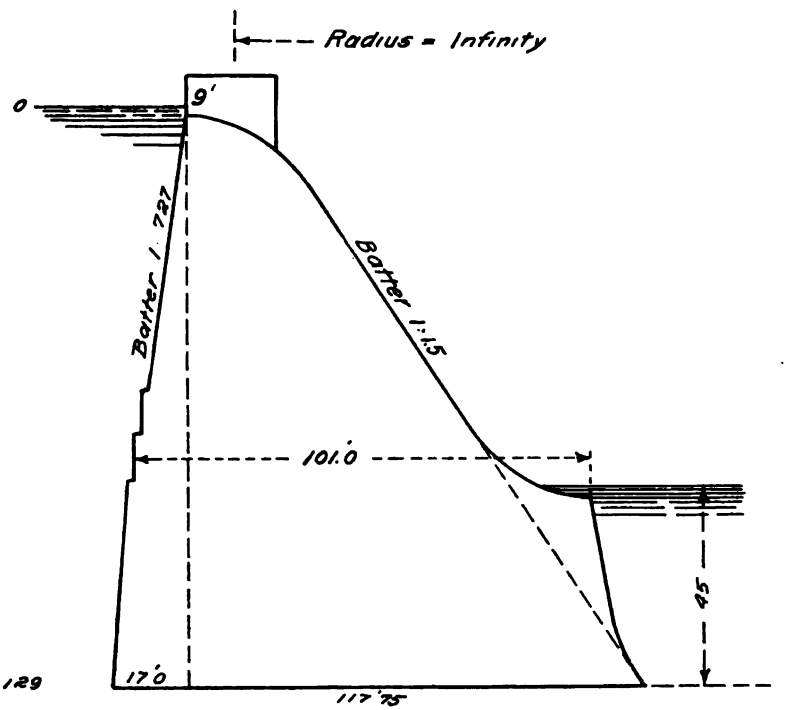
esis, it is not unreasonable to assume the former distribution will describe fairly closely the facts until we have greater knowledge.

"4. In future we hold that in the first place masonry dams must be investigated for the stability of their vertical sections. If this be done we feel pretty certain that most existing dams will be found to fail, if we accept the criteria of stability usually adopted for their horizontal sections. This failure can be met in two ways: (*a*) By a modification of the customary cross-section. We think it probable that a cross-section like that of the Vyrnwy dam would give better results than more usual forms; (*b*) by a frank acceptance that masonry, if carefully built, may be trusted to stand a definite amount of tensile stress. It is perfectly idle to assert that it is absolutely necessary that the line of resistance shall lie in the middle third for a horizontal treatment, when it lies well outside the middle third for at least half the dam for a vertical treatment."



VYRNWY DAM

FIG. 1.

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Immediately upon the publication of the preceding results, Sir Benjamin Baker undertook some experiments of a like nature.* The models employed by him were made of ordinary jelly, and included not only the transverse section of the dam itself, but the rock upon which it rested as well. It is shown in the figure.

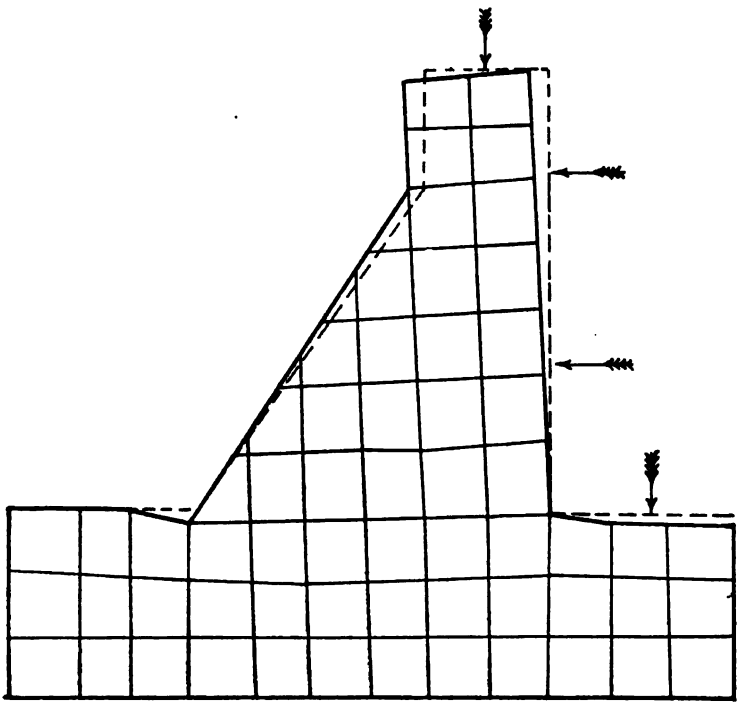

FIG. 2.

The horizontal and vertical lines drawn on the sides of the model were for the purpose of detecting any distortion that might result through the application of pressure. These pressures were applied against both the upstream face and the rock floor of the reservoir, as it was believed that, while according to the theory of the middle third there could be no tension in the heel, nevertheless for the case of reservoir full, fairly severe tension in the masonry might thus be caused.

The experiments indicated that the distribution of shearing stress

* Vol. CXLII. "Minutes of Proceedings of the Institution of Civil Engineers."

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in the plane of the base, *i. e.*, where the dam met the rock, was more nearly uniform than parabolic, and that the strain extended into the rock for a distance equal to about half the height of the dam before it became undetectable. To solve the complete problem, therefore, it would be necessary to consider the elasticity of the rock on which the dam rested.

Partly as a result of these and the previous experiments, it may be pointed out in passing, the proposed increase in elevation of the Assouan dam, whereby the capacity of the reservoir would have been considerably augmented, was indefinitely postponed.

The new feature in Atcherley's analysis is that, even though the condition of "no tension in a horizontal joint" is satisfied, dangerous tensions may be shown to exist across vertical planes.*

In connection with this consider, for example, a section of the dam *ABC*, which is triangular in profile, and construct *BEC* so that the ordinates represent the variation of the unit normal stress over the horizontal joint *BC*.

Taking a vertical section *IK*, in which *J* locates the centroid, the forces to the left are the upward pressure acting over *BK*, tending to cause rotation in a clock-wise manner and thus produce tension at *K*, and two counteracting forces tending to neutralize this pressure: the weight of the portion *BKI*, and the horizontal shearing force acting along *BK*. The resultant effect of all three will be tension at *K* provided the rotation is right-handed, with a consequent splitting along the vertical plane *IK*.

In view of the fact that the horizontal shear is present as a factor, it is necessary to determine its distribution, and this Professor W. C. Unwin undertook to do.* Instead however, of accepting the distribution in accordance with Atcherley's assumptions, an analysis was attempted by which the shear might be actually calculated, and in doing so attention was called to the fact that the accepted theory of dam design is incomplete in just that feature, since it fails to consider the rate of change in the horizontal shear.

In any analysis the fundamental assumption must be made that

* "Engineering," Vol. 79, p. 414, 1905.

* "Engineering," Vol. 79, p. 513. "Note on the Theory of Unsymmetrical Masonry Dams," by W. C. Unwin.

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a masonry dam is a homogeneous, elastic solid, and, while it is not absolutely essential that no tension exist at any point in the cross-section, yet it seems desirable that there should be none at the upstream face of horizontal joints.

It may be said therefore that for a more exact analysis, the problem resolves itself into one of the determination of shear on horizontal planes and Professor Unwin suggests as follows a method of procedure by which this may be accomplished.

If, as in the figure, we assume a dam of triangular section, in

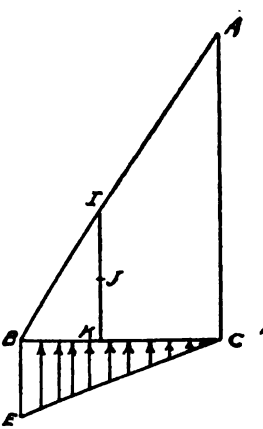

FIG. 3.

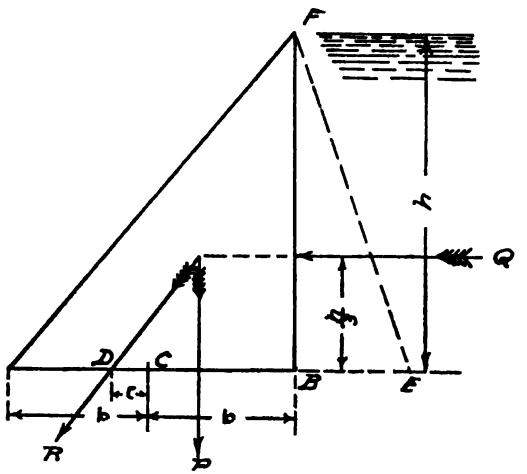

FIG. 4.

which AB is some horizontal joint, other than the base, and C its centroid, then Q will represent the water thrust, P the weight of masonry, and R their resultant.

In agreement with the ordinary theory we may write the well-known formula for the unit normal pressure on a horizontal joint, at any point x, measured from A, as follows:

$$P_n = \frac{P}{2b}\left\{1 + \frac{3c(b-x)}{b^2}\right\} \qquad (5)$$

For the horizontal shear we must proceed further. Consider, therefore, the forces to the left of HK in Fig. 5; we have (1) the vertical pressure on AK, (2) the weight of AHK, and (3) the

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shear acting along AK. It is evident that the difference between (1) and (2) represents the total vertical shear on HK.

If therefore, the figure $ALMB$ represent in masonry units, the distribution of normal stress on AB, as given by equation (1), then $ALTH$ will, in like manner, represent the above mentioned total vertical shear on HK.

Consider now a second section, $A'B'$, a small distance z above AB; the total shear on HK' may then be found as before. Denoting the former by S, and the latter by S', then $S - S' =$ the total

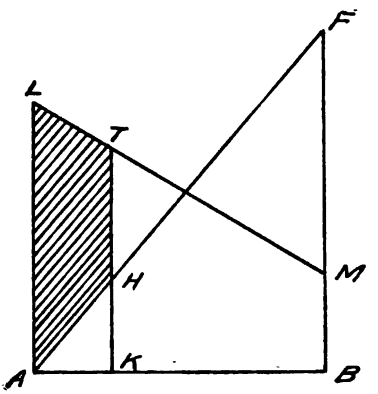

FIG. 5.

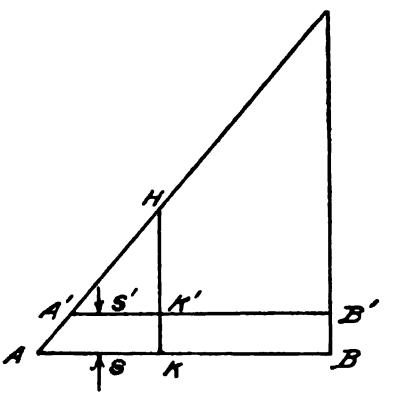

FIG. 6.

shear on KK', which, when divided by z, will give the intensity of vertical shear at K, and consequently the intensity of horizontal shear at the same point.

Since all the forces to the left of HK are now known, the normal stress on that plane may be found, and from it we may readily determine whether tension or compression exists at K.

At the base these results would be much modified, because of the discontinuity of form, and in the opinion of Professor Unwin places the exact determination of the stresses beyond the power of mathematics. The authors believes also that the effect of the rock into which the dam is built is to reduce the variation of stress which would otherwise exist.

In a subsequent paper,* giving a complete demonstration of the

* "Engineering," Vol. 79, p. 593. "Further Note on the Theory of Unsymmetrical Masonry Dams," by W. C. Unwin.

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preceding analysis as applied to a masonry dam of triangular cross-section, it is found that the distribution of shear on a plane horizontal joint may be represented by a right triangle whose base is the width of the joint and whose vertex is perpendicularly below the down stream edge. The figure illustrates the variation of normal stress and shear on AB; the lines of resistance for both vertical and horizontal planes, and the centers of gravity of the sections above the successive horizontal joints.

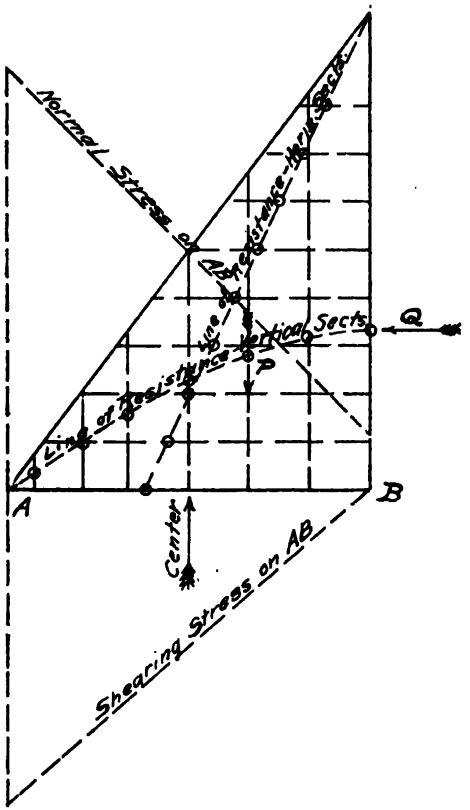

FIG. 7.

Consequently the total normal or shearing stress on any part of AB is equal to the area between that part and the line of normal stress or the line of shearing stress.

If the upward reactions and downward weight of the dam to the

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left of each vertical section be combined with the shears T, acting along AB, the resultants will cut the vertical section at points shown on the line of resistance for the vertical sections. As this line lies wholly within the middle third, there can be no tension on any vertical section.

The total compressive stress on any vertical section at its lower edge will therefore be

$$\frac{T}{y}\left(1+\frac{6z}{y}\right). \qquad (6)$$

where T is the shear on the horizontal plane from the toe to the vertical section taken, y the height of the vertical section, and z the distance from the center of the vertical section to the point of application of the resultant forces on that section.

Near the upstream toe the plane on which the greater principal stress acts is found to be vertical, while near the downstream toe it approaches the horizontal. The stresses are all compressive and on the water face the compressive stress is at all points equal to the water pressure at that point.

The above analysis is simply an application to vertical sections of the method now accepted as applicable to the horizontal planes and is a possible solution, since the distribution of shear is known. It differs from Atcherley's method in the fact that the latter assumed that the usual distribution of *normal* stress obtained, while *a parabolic variation was assumed for the horizontal shear.* This latter assumption the author thinks inconsistent with the previous one. No mathematical method for the determination of the stresses at the base is possible because of the changed conditions there.

Further investigations by Professor Unwin* on dams of various sections lead him to the following conclusions:

1. For a rectangular dam the distribution of shearing stress on horizontal planes may be represented by the ordinates of a parabola.

2. For a triangular dam, the distribution may be represented by the ordinates of a triangle with the apex below the downstream toe.

3. For a dam with vertical upstream face and curved downstream face, the distribution may be represented by a figure consisting of a parabola superposed on a triangle.

* "Engineering," Vol. 79, p. 825. "On the Distribution of Shearing Stress in Masonry Dams," Professor W. C. Unwin.

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4. For a dam with rectangular base the distribution is represented by a parabola.

Following the experimental investigations of Atcherley and Baker, several other papers of a like nature appeared in the minutes of *Proceedings* of The Institute of Civil Engineers, Vol. CLXII. The first of these to be considered here is that by Sir John Walter Ottley and Arthur William Brightmore, entitled "Experimental Investigations of the Stresses in Masonry Dams Subjected to Water-Pressure."

In presenting this paper, the authors drew attention to the fact that until the publication of Mr. Atcherley's results, the question of dam design had been accepted as settled, and that his memoir had had the effect of reopening the entire subject of the distribution of stress in structures of this class.

It was also pointed out that tension was found by him to exist on vertical planes near the outer toe, whether the distribution of shearing stress over the base was assumed to be uniform or to vary according to the parabolic law.

Considering a transverse section of a dam, the authors argued that, whatever the distribution of shear over the base might be, it must follow some other law near the top, since the conditions in these higher levels were radically different from those existing at the base, where the dam was fixed to the foundation, and where the water pressure ceased abruptly.

The investigation was therefore undertaken, at least in part, to determine the distribution of shear on horizontal planes in the higher levels of the dam and to see how it varied from that at the base; and it might be stated here that it was found to be uniform in the latter plane, but to vary uniformly from zero at the heel to a maximum at the toe, in the higher levels, the change from one condition to the other being gradual. It will also be shown that it is near the inner toe rather than near the outer toe that tension may be anticipated.

The model dams were triangular in section, made from a kind of modelling clay called "plasticine," and so proportioned that the resultant pressure on the base cut that plane at the downstream extremity of the middle third.

For purposes of observation the sections were placed between

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vertical sides of plate glass, upon which vertical and horizontal lines had been etched, corresponding to similar lines on the model, so that any displacement in the latter might be noted by comparison with the former. Pressure was applied by means of a thin rubber bag containing water which was made to fit the frame. Though the water was allowed to act over a period of 33 days, after the lapse of one week a crack was noticed at the upstream toe, running downward and at an angle of about 45°. At the end of the longer period an examination showed that in the neighborhood of the base the displacement of the vertical lines was such as to make them all about equally inclined, thus indicating a uniform intensity of shear on that section, while in the higher levels and near the outer portion of the dam, the lines became more inclined as the elevation increased, indicating that the intensity of shear increased also as the top was approached.

Turning to the horizontal lines in the model for the purpose of discovering the method of distribution of normal stress, it was found that they were curves at the base, sloping downward from the inner toe to a point about two thirds the distance to the outer toe, then remaining fairly level until almost reaching the downstream face, when they finally bent up slightly. In the higher levels, however, these lines gradually developed a uniform slope running from the inner to the outer toe.

An investigation of the shearing stresses on vertical planes in the model indicates that, "To draw the line representing the intensity of normal reaction at the base the following facts must be borne in mind:

"1. The total normal reaction equals the weight of the dam.

"2. Since the resultant pressure on the base acts at one third the width from the outer toe, the moment of the reaction stresses about this point must be zero.

"3. The intensity of the reaction at the outer toe must equal the intensity of the shearing stress in the vertical plane multiplied by the ratio of the height to the base of the dam."

Referring to the figure: AB represents the base of the dam and BC twice the average intensity of normal stress on AB. AC is then drawn. Consequently ABC represents the total normal stress on AB, or the weight of the structure.

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If AE, on the other hand, represents the actual intensity of normal reaction over AB, then for (1) to hold true, the area Y must equal the areas $(X+Z)$ and if (2) is to hold, then the mo-

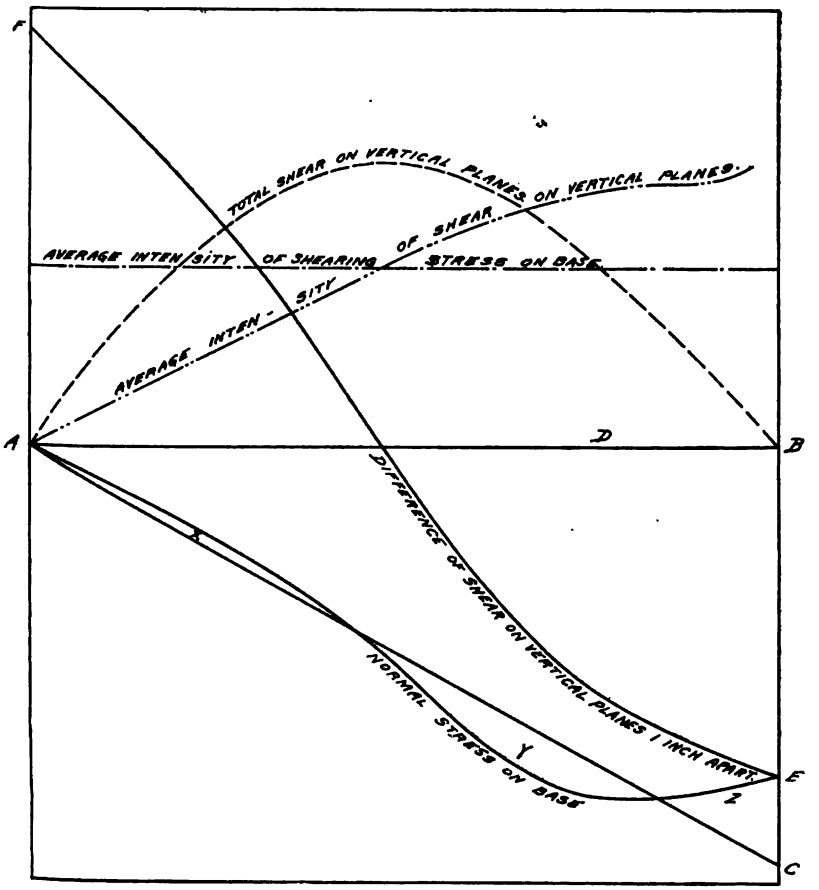

FIG. 8.

ments of X, Y and Z, about D (equal to $\frac{1}{3}$ AB from B) must be zero; also for (3) to be satisfied, BE must equal the limiting value of shearing stress in a vertical plane near the toe, multiplied by the height and divided by the base of the dam.

From these considerations AE may be fitted in by trial till it is found to satisfy all of the above conditions.

Dividing the cross-sections into strips one inch wide we may

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properly consider the equilibrium of each such strip. Evidently the difference between the weight of each strip and the normal reaction on the base is equal to the difference in shear on the two adjacent vertical planes and if in the figure these weights be plotted upward from *AE*, the curve *FE* will result. Furthermore both the curves for "total shear on vertical planes" and "average intensity of shear on vertical planes" may now be drawn, whereupon it is evident to what extent the average intensity of shear on vertical planes varies and how it compares with the average intensity on the base.

Since the shear on horizontal and vertical planes at any one point is equal, and the shear on the base is practically constant, it follows that above the base the shear on horizontal or vertical planes is small near the heel, while in the outer half above the base it increases as the outer edge is approached. In fact it increases from zero at the heel to a maximum at the toe. These facts show that the shearing stresses to be provided for are those existing in the higher levels and near the toe, and not those at the base.

In considering the effect of shear on the base, neglecting the "fixing" at that level, we may assume that the reaction stress and that due to the weight of a strip is constant over each inch. They then act at the middle of each strip; and, taking these points successively as centers, the difference of the moments of the horizontal pressures on the vertical sides of the strip, it is evident, will equal the sum of the shearing stresses on the same vertical sides multiplied by one half inch.

This makes possible the determination of the moment of the horizontal pressures on each vertical strip.

The horizontal shear on each inch of base being the difference between the horizontal pressures acting on the two vertical sides, the latter may be determined as soon as their points of application are given. As these points are known for the innermost and outermost strip, an easy curve may be drawn which will approximately locate the other points and thus give the desired heights. From these results it may be shown that the shearing stress on the base increases from practically zero at the inner toe to a point near the center of the base and then remains fairly constant.

The modification of this distribution, due to the fixing of the

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dam at its base, must on the other hand be considered. The water tends to cause a maximum pressure and displacement at the inner face which diminishes to zero at the outer. As the dam is fixed, this displacement is prevented, thus inducing corresponding shears, and the effect of this conflicting condition, with that previously shown to exist, causes a nearly uniform shear over the base.

Further evidence of uniform shear on the base was obtained as follows: The models, after being subjected to water pressure, showed cracks which appeared at the inner toe, the angles which these made with the horizontal steadily diminishing as the base was decreased in width from a maximum of 45° for the widest base used to 25° for the narrowest.

The variation of these inclinations corresponded closely with the computed directions, on the assumption that the shear was uniform over the base and the experiments therefore strongly support the inference that shear over the base is uniformly distributed.

It was shown by means of the models that there are tensile stresses on other than horizontal planes passing through the inner toe. The models indicated this by cracking, even when the back was sloped away from the vertical so as to cause vertical pressure and hence compression on the upstream face.

The impossibility of tension on vertical planes near the outer toe may be shown by means of the following equation for principal stresses:

$$f = \frac{p + p' \pm \sqrt{(p + p')^2 - 4(pp' - q^2)}}{2} \qquad (7)$$

where compressions are plus and tensions are minus. When $pp' > q^2$ at any point, there can be no tension at that point, since under the above conditions both principal stresses will be compression, and hence stresses on all other planes passing through that point will be compression also. This condition may be shown to exist near the outer toe, and hence no tension can act across any vertical plane in that position.

For example consider the equilibrium of a wedge of unit length cut off by a vertical plane near the toe.

p' = intensity of pressure normal to a vertical plane at base.

p = intensity of reaction normal to the base.

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q = intensity of shearing stress.

Then $p'h = qb$

or
$$p' = q\frac{b}{h} \tag{8}$$

The weight of the particle is negligible because it varies with h^2.

Since the resultant stress must be parallel to the outer profile it follows that

$$p = q\frac{h}{b} \tag{9}$$

Multiplying (8) by (9) there results:

$pp' = q^2$ at outer toe. But p has been shown to increase for some distance from outer toe and the point of application of p' becomes relatively lower as the inner toe is approached, and since the average pressure is constant it follows that p increases as the distance from the outer toe increases, and hence in the vicinity of the outer toe pp' is greater than q^2, and consequently there can be no tension in that neighborhood. This was checked by the behavior of the models.

It is a fact that in dam work the normal stress is the only one specified, whereas the absolute maximum as shown above is about 50 per cent. greater.

The conclusions reached from this set of experiments follow:

1. "If a masonry dam be designed on the assumption that the stresses on the base are uniformly varying and that the stresses are parallel to the resultant force acting on the base, the actual normal and shearing stresses on both horizontal and vertical planes would be less than those provided for."

2. "There can be no tension on any planes near the outer toe."

3. "There will be tension on certain planes other than the horizontal, near the inner toe and the maximum intensity of such tension in the foundation being generally equal to the average intensity of shearing stress on base, and the inclination of its plane of action being about 45°; and its maximum intensity in the dam above the base about one half the above amount and acting on a plane less inclined to the horizontal."

The investigation undertaken by Mr. Hill* for "the determina-

* Minutes of Proceedings of the Inst. of C. E., Vol. CLXXII.

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tion of the stresses on any small element of mass in a masonry dam," are, on the other hand, purely analytical in character, being directed toward a solution of (1) the vertical, (2) horizontal, and (3) tangential shearing forces acting on the faces and along the edges of such an element.

In this analysis there is first expressed a perfectly general formula for C (the distance of the load point from the center of the joint), and two other general formulæ for the pressures p_1 and p_2 in terms of the total load and C from its above value, where p_1 is the minimum and p_2 the maximum pressure. For the pressure p at any point x on the joint of length b the following equation is used:

$$p = p_1 + \frac{x}{b}(p_2 - p_1). \qquad (10)$$

Up to this point the analysis is identical with the general procedure of investigation, which assumes that the horizontal pressures are proportional to the vertical, and does not analyze the shear.

Citing Prof. W. C. Unwin, the author states that the former "suggested that the shearing stress at any point might be found by considering the difference between the total net vertical reactions (between that point and either face) along two horizontal planes a unit's distance apart, and has applied the principal by the use of algebraical methods." Mr. Hill, on the contrary, employs the calculus to obtain more rigorous results.

The procedure follows: Consider any point distant x from the inner toe and on the lower of two horizontal planes, a unit's distance apart. The total vertical reaction is then

$$\int_0^x p\,dx.$$

Subtracting the weight of masonry resting on this portion of the horizontal joint, and denoting the difference by r, we have an expression for the "net vertical reaction." If this value of r be differentiated with respect to h, the distance between the two horizontal planes, the change in the reaction will be obtained, and this change or difference is the vertical shearing stress at the point

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located by x. It is also therefore the horizontal shear at the same point, which we may denote by q.

If q be integrated with respect to x, between the limits of x and b, the resulting expression will give the entire horizontal shear between such limits on the joints in question. Represent this by Qx.

To find the horizontal pressure intensity, we have but to consider the above integration. This shear must be resisted by the material along the vertical section at x. Similarly the total shear on a plane a differential distance below the last must be resisted by the vertical section at x, differing in height from the former by dh. Consequently the differential of Qx with respect to $h = p'$ will represent the horizontal pressure intensity at point x. These expressions for p, p' and q therefore give respectively the values of the vertical pressure intensity, horizontal pressure intensity and shearing force acting on a unit element of mass.

Cain* presents a treatment of this matter, which, while presenting no new features, is strictly arithmetical in character, and in that respect at least differs from the preceding. Its purpose, as Hill's, is to determine the amount and distribution of stress at any point in a masonary dam, on the assumption that the law of the trapezoid represents the variation of pressure on horizontal joints.

The analysis finally establishes formulæ for (1) the normal unit stress at any point in a horizontal joint, (2) the normal unit stress on a vertical plane at any point of a horizontal joint, (3) the unit shear on either horizontal or vertical planes at any point of a horizontal joint, and at the same time indicates the method of determining the maximum and minimum normal stresses and the planes on which they act.

The solutions are only approximate, but the results are found to be close enough for the purpose.

Before proceeding it may be advisable to review certain features involved in a consideration of the stresses in a masonry dam which Professor Cain presents in a very satisfactory manner.

1° It will be evident from an examination of the figure that the intensities of shear on two planes at right angles to each other, are equal. For, in the elementary cube under consideration, the weight

* Wm. Cain, M.Am.Soc.C.E., *Trans. Am. Soc. C. E.*, Vol. LXIV., p. 208.

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may be neglected since it is an infinitesimal of the third order, while the opposing normal forces balance as the cube is reduced in size.

For equilibrium then, $q \cdot a \cdot a = q' \cdot a \cdot a$, or $q = q'$, and, because each side is a differential quantity, it may be assumed that the values

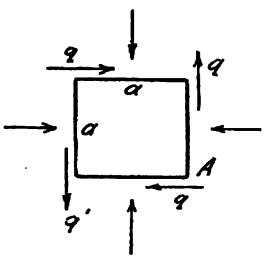

FIG. 9.

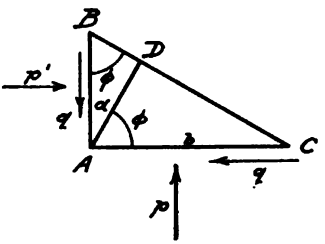

FIG. 10.

q and q' represent the average unit shear on the respective faces. As a consequence they are equal to the shear at any point, for example A, of the particle.

2° In a triangular element of the dam, at the down stream edge, and of units length, the forces acting are those shown. Because it is an element we may neglect the weight, and therefore, if p' is the normal intensity of stress on a vertical plane, p the normal intensity of stress on a horizontal plane, and q the shear intensity, for

$$\Sigma V = o \quad pb = qa \quad \text{or } p = q\frac{a}{b} \text{ and } q = p\tan\phi. \tag{11}$$

$$\text{for } \Sigma H = o \quad p'a = qb \quad \text{or } p' = q\frac{b}{a} \tag{12}$$

$$\text{then } p' = p\tan^2\phi \quad \text{or}$$
$$pp' = q^2 \tag{13}$$

3° The same analysis may be applied to an element at the inner face where ϕ' is the inclination to the vertical; but, for the reservoir full, the intensity of water pressure, horizontal or vertical, at c, and in this case represented by w, must be taken into account. Under these circumstances,

$$pb = qa + wb \quad \text{and } p'a = qb + wa \tag{14}$$
$$\therefore p = q\cot\phi' + w \quad \text{and } p' = q\tan\phi' + w \tag{15}$$

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When, as is usually the case, the vertical component of water pressure acting along the back is neglected, the above equations become

$$p = q \cot \phi' \qquad p' = q \tan \phi' + w \qquad (16)$$
$$\therefore q = p \tan \phi' \qquad \text{and } p' = \tan^2 \phi' + w. \qquad (17)$$

4° If an element at the downstream face be again considered, since the shear on the outer face DC is zero, that on a plane AD

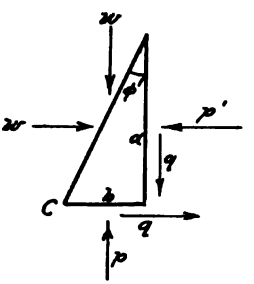

FIG. 11.

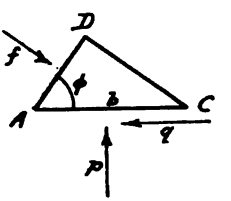

FIG. 12.

perpendicular to DC, must be zero also, and hence the stress "f" on AD is wholly normal.

The total pressure on AD is therefore $f \cdot AD = f \cdot b \cdot \cos \phi$. The vertical component of this is $f \cdot b \cos^2 \phi$.

$$\text{Because } \Sigma V = O \qquad pb = f \cdot b \cos^2 \phi$$

$$\text{or } f = \frac{p}{\cos^2 \phi} = p \sec^2 \phi \qquad (18)$$

which is the maximum intensity of normal stress at the outer face.

5° To determine the planes of principal stress, *i. e.*, planes upon which the stress is wholly normal, and also the intensity of that stress, we may assume the conditions indicated in the figure.

The total shear on c then is fc; its vertical component $fc \cdot \cos \theta = fb$, and its horizontal component $fc \sin \theta = fa$.

When $\Sigma V = o$ and $\Sigma H = o$

$$fb = pb + qa \quad \therefore f - p = q \tan \theta \qquad (19)$$
$$fa = qb + p'a \quad \therefore f - p = q \cot \theta \qquad (20)$$

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The difference of these two equations gives

$$p - p' = q\,(\cot\theta - \tan\theta) = q\,\frac{1 - \tan^2\theta}{\tan\theta} \qquad (21)$$

$$\therefore \tan 2\theta = \frac{2\tan\theta}{1 - \tan^2\theta} = \frac{2q}{p - p'} \qquad (22)$$

This equation gives a plane upon which there is none but normal stress.

To determine f, multiply equation (19) by (20).

$$(f - p)(f - p') = q^{-2} \text{ whence}$$
$$f = \tfrac{1}{2}[p + p' \pm \sqrt{(p + p')^2 - 4(pp' - q^2)}].$$

This will give two values of f, which correspond to the two principal planes of stress, the stress being compressive when f

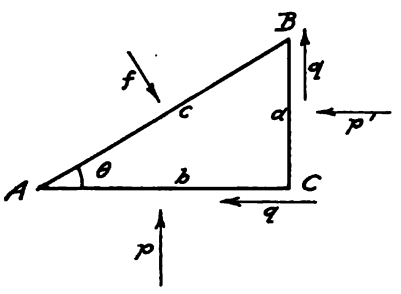

FIG. 13.

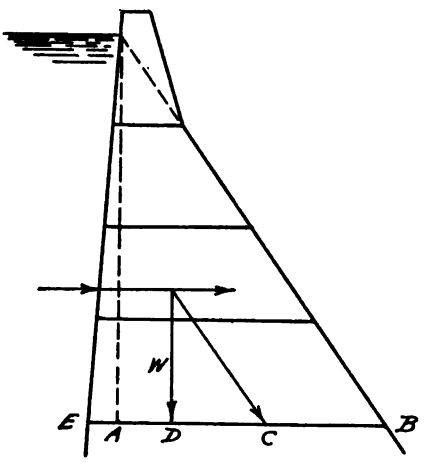

FIG. 14.

is positive, and tensile when f is negative. There can be no tension when $pp' > q^2$.

Determination of the vertical unit stress at any point of a horizontal plane joint: From the law of the trapezoid, we have the pressures at the upstream and downstream toes represented respec-

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tively as follows:

$$p_2 = \frac{4b - 6EC}{b^2} W \tag{23}$$

$$p_1 = \frac{4b - 6CB}{b^2} W \tag{24}$$

The resultant is supposed to act within the middle third.

If x' represent any point along EB, measured from E, then p the pressure at x' is given by,

$$p = p_2 + \frac{p_1 - p_2}{b} x' \tag{25}$$

while the total normal stress from E to x' is, by integration,

$$P = p_2 x' + \frac{p_1 - p_2}{2b} x'^2 \tag{26}$$

To find the unit shear on vertical or horizontal planes, we have but to consider a slice of dam between two horizontal joints one

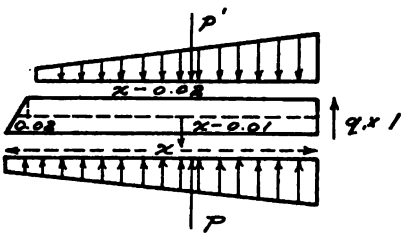

FIG. 15.

foot apart, extending from the inner to the outer face, a distance x along the lower joint.

(The back is supposed to slope $\frac{0}{100}$ ft. for each foot in height.)

The vertical forces acting are:

1. A uniformly varying stress on the upper joint acting downwards.
2. The same on the lower joint acting upward.
3. The weight of the strip.
4. The shear on the vertical fact at x.

For equilibrium, $q_1 = P' - P + (x - 0.01)$.

P' and P may be obtained as indicated in the previous demonstration.

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The above value of q_1 is the average unit shear at the depth taken, but a similar value q_2 may be determined at a depth one foot below. Under these circumstances $(q_1 + q_2)/2$ is the average of

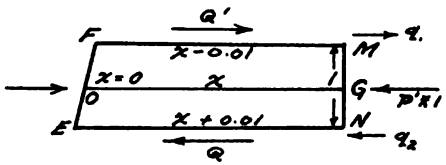

FIG. 16.

the two, and may be said to be approximately equal to the shear at the depth of the joint between the two slices.

To find the normal unit stress on a vertical plane, a similar section to that just used may be employed; but the horizontal components are now to be equated for equilibrium.

Let h = the horizontal water pressure at the assumed depth.

Q' = total shear on upper face.

Q = total shear on lower face.

p' = average normal stress.

q_1 and q_2 = the intensities of horizontal shear at the points indicated.

Q' and Q may be found by integrating q_1 and q_2 between the proper limits.

$$\therefore p' = h + Q' - Q. \qquad (27)$$

This value of p' is assumed as the average intensity on the vertical plane and as the unit intensity on the vertical plane at a point midway between the two horizontal planes.

Three general formulæ may be written for p, q and p', which, it has been suggested, may be put in the following form:

$$p = a + bx,$$
$$q = c + dx + ex^2,$$
$$p' = f + gx + hx^2 + jx^3.$$

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A BRIEF DESCRIPTION OF THE GOW GANDA SILVER DISTRICT IN ONTARIO, CANADA.

By PERCY R. ISEMAN.

Gow Ganda is situated almost at the middle point of a line drawn from Toronto to the southern arm of Hudson's Bay. It is situated in the heart of a much glaciated region where lakes and streams are numerous. The region has been very recently opened. The first discovery was made approximately August 5, 1908. The means of access are still very limited. In the summer the only method of reaching the camp is by a canoe route passing through the Montreal River and a chain of lakes. This canoe route starts at Elk Lake and is some 50 miles long. Numerous portages are necessary, so that the trip is very protracted. It involves the handling of freight and is therefore expensive. From Elk Lake to Latchford there is a steamboat line down the Montreal River about 50 miles long. Four portages are necessary, and hence the freight rate from Latchford to Gow Ganda is very high. Latchford is reached from Toronto via the Temiskaming and Northern Ontario Railroad, a distance of about 350 miles. In the winter the camp is attainable by a road 54 miles long from Charlton, a town located on a spur from the Temiskaming and Ontario Railroad. There is also another route in the winter from Sellwood; the road is about 70 miles long. In the summer time all the travel in the Gow Ganda district is done in canoes, as there are no roads and but few trails through the forest.

Topography.

As has already been stated, the country is extensively glaciated and deposits of sand and gravel are widespread. The sand permits the growth of jack-pine, poplar, birch and balsam. The soil cap however is very shallow and in most instances bedrock can be found at a depth of not more than 4 feet and in many cases much less. The district is not mountainous and indeed few hills attain a height

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of much over 200 feet. These hills or ridges have a general north and south direction. The lakes are usually shallow and contain water of exceptional clearness and purity. The climate in the summer is excellent, rarely does the thermometer go above 80° and the nights are quite cold. In the winter the mercury often drops to 40 or 50° below zero. The lakes are ready for winter travel toward the end of November and the ice goes out about the end of May.

Geology.

The rocks of the district are all pre-Cambrian. A. G. Burrows in a Report of the Ontario Bureau of Mines, Vol. XVIII., Part 2, classifies them as follows:

Post-Middle Huronian.
Diabase, Igneous contact.

Huronian.
Greywacke, quartzite, arkose.
conglomerate and slate.
Great unconformity.

Laurentian.
Granite, syenite, gneiss.
Intrusive contact.

Keewatin.
Greenstone schists.
Altered basic rocks, and some
acid porphyries.

These rocks are widely distributed and excellent contacts can easily be found. Contrary to experience at Cobalt, most of the discoveries of silver have been made in the diabase, although the Keewatin is not to be ignored. So far the quartzites, slates, etc., have not been productive, but too little development work has been done to form a fair judgment. The silver deposits are clearly the product of expiring igneous action. The white metal occurs in cracks and fissures which have been formed by the anticlinal folding to which the diabase has been subjected on cooling. Confidence in the igneous theory has led to the belief that the ores will continue in depth. This conclusion however, is purely theo-

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retical since the deepest shaft in the district is only a little over 100 feet deep. The silver appears in veins along with pyrite, chalcopyrite, bornite and galena. The gangue is generally calcite and may be pure or siliceous. The prospectors believe, and with some justification, that they have a good outlook when a calcite vein shows cobalt bloom and occurs in diabase or gabbro. One vein in particular was very interesting and quite typical. The native silver constituted nuggets in the midst of a black alteration product. The vein was about an inch and a half wide and ran high in silver. The black material was probably due to the decomposition of copper, nickel, and cobalt minerals. One advantage possessed by the Gow Ganda ores over those from Cobalt is that they do not contain so much arsenic. Prospecting in the region around the Gow Ganda Lake is rendered extremely difficult by the exces-

Photo—W. F. Battersby.

FIG. 1. Contact of Laurentian and Huronian. (*G*) Granite; (*C*) Angular and rounded fragments of Granite; (*Q*) Quartzites.

sive tightness of the rock. (Fig. 1.) In conclusion it is fair to say that Gow Ganda is a very promising district. Its area is much greater than that of Cobalt and some very rich strikes have been made, thus boding well for its future.

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Mining.

Practically very little has been done in actual mining except on a few properties. The assessment work is usually performed in the summer and consists chiefly of trenching and sinking test pits in promising places. On the properties which are actually mining both open cut and underground work is being practiced. At the Bonsall mine a shaft 50 feet deep has cut several veins carrying silver. Shipping ore was being removed. At the Boyd-Gordon a shaft had been sunk and a compressor had been installed. Work was also in progress in an open cut. (Fig. 2.) The same condi-

Photo—Can. Geol. Sur.

Fig. 2. Open cut—Boyd-Gordon Mine.

tions prevail at the following properties: The Mann, the Reeve-Dobie, the Bartlett, and others. As a rule development work is just beginning and very little can be said about the future.

Economic Conditions.

On account of the remote situation the cost of living in Gow Ganda is very high. Last winter teamsters received as much as $4

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per 100 pounds for bringing freight from Charlton, and towards the end of the season even as high as $100 a trip. Conditions this winter will be perceptibly better on account of the government road from Elk Lake. The houses are built principally of logs, rough hewn and notched together. To give an idea of the market prices last summer, the following figures may be cited: Flour was sold for $8 per 100, bacon 25 cents per pound and fresh meat was not obtainable. Unskilled labor commanded $2.50 per day and machine men received from $4 to $4.50. The town of Gow Ganda then contained a population of 500, but like all mining camps the number varies greatly. One of the greatest handicaps the district labors under is the terrible epidemic of black flies and mosquitoes, which render surface work almost impossible from the middle of June till the end of July. In conclusion Gow Ganda may be described as having sprung into existence over night. It has already made wonderful strides and twenty cars of ore will probably be shipped this winter. Certainly had it possessed a railroad at the outset as did its sister camp Cobalt, its growth would have been more rapid.

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ABSTRACTS OF RECENT MINING DECISIONS.*

LOCATION OF CLAIMS.

Location of Placer Claim—Notice.

A notice locating a placer claim, which was partly printed and partly written, read as follows: "Notice is hereby given that the undersigned in compliance with the requirements of the Revised Statutes of the United States have this day located the following described placer mining ground, viz: Commencing at the S. W. 1-4 of the N. E. 1-4 of Section twenty-three (23) T. 14 N., R. 10 E., situate in the Brushing Mining District, County of Placer, State of California. This claim shall be known as the Canothus Placer Mining Claim. Located on the seventh day of September, 1905. (Signed)." The words "commencing at" were in the printed form, while the balance of the description was written, and while it did not appear that these two words were inadvertently left in the notice, still from testimony of the locators, it was clear that they intended to locate the southwest quarter of the northeast quarter of the section described and that the words "commencing at" were expressionless and to be disregarded. And under the rule that location notices should be liberally construed, having reference to the circumstances under which and the character of the parties by whom they are generally given, and that the purpose of such notice is to identify the land claimed with reasonable certainty, the notice was held sufficient.

Green *v.* Gavin, (Cal.) 101 Pac. 931, March, 1909.

Location of Mining Claim—Qualification of Locator.

Private persons in actions between themselves where the United States is not interested and is not a party can not question the qualification of a locator of a mining claim, so far as its validity is affected, by reason of his being a foreigner.

Holdt *v.* Hazard, (Cal.) 102 Pac. 540, April, 1909.

Location of Mining Claim—Actual Possession.

Where persons make a valid location of a mining claim on the public domain and in accordance with the United States statutes, their right of possession will continue until they have, in fact, abandoned or forfeited the claim by failure to do the required amount of work within the prescribed time; they are not required to keep an actual possession of the claim.

Holdt *v.* Hazard, (Cal.) 102 Pac. 540, April, 1909.

*Prepared for the School of Mines Quarterly, by J. W. Thompson, Attorney-at-Law, Indianapolis, Indiana.

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LOCATION OF MINING CLAIM—MARKING BOUNDARY.

Where notices were duly posted upon each of several mining claims located on the public lands, and which notices designated the place of posting as the starting point, and where they contained calls and distances to certain stakes at the four corners of each claim, the area of which was six hundred feet by fifteen hundred feet, and the stakes thus called for were set and in some instances stones were piled around them, this was said to be a sufficient marking of the claims.

Holdt *v.* Hazard, (Cal.) 102 Pac. 540, April, 1909.

LOCATION OF MINE—DECLARATORY STATEMENT.

A declaratory statement describing the development work of a mine read as follows: "At the point of discovery a cut, the dimensions of which are 5 by 11 feet and 5 feet in depth, along the course of the vein has been run"; and in an amended declaratory statement it was stated that the locator within thirty days after posting his notice of location "did distinctly mark said location upon the ground, so that its boundaries could be readily traced, and did dig a cut at the point of discovery of the following dimensions, to wit: 5 feet wide 15 feet long and 10 feet deep at the face of the cut." And the notice contained another statement as follows: "At the point of discovery said locator and claimant has dug a cut the dimensions of which are 5 by 15 feet and 10 feet in depth in which is disclosed a well defined vein, crevice or deposit of ore at a vertical depth of at least 10 feet below the lowest point of the rim or collar of said discovered cut at the face of said cut at the surface." Both the original and amended declaratory statements were filed within the required time after the notice of location was posted. While these declaratory statements did not comply technically with the requirements of the statute, the court said there was in them at least a substantial compliance, and that this was all that has ever been required.

Butte Northern Copper Co. *v.* Radmilovich, (Mont.) 101 Pac. 1078, May, 1909.

SINKING DISCOVERY SHAFT.

A locator is not required under the statute of Montana to sink his discovery shaft at the point of discovery.

Butte Northern Copper Co. *v.* Radmilovich, (Mont.) 101 Pac. 1078, May, 1909.

LOCATION NOTICE.

Under a statute providing that the locator of a mining claim should post his notice of location at the point of discovery, a locator posted his notice at a different place, but thereafter posted it at the point of discovery and in an action by a conflicting claimant and as against his intervening rights, the location of the original locator was postponed to the date when he posted the notice at the point of discovery, as the statute required. And where the location notice described the vein as north and south, it was held sufficient to support a location of a claim along a vein east and west.

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Butte Northern Copper Co. *v.* Rádmilovich, (Mont.) 101 Pac. 1078, May, 1909.

LOCATION OF MINE—CHANGE IN BOUNDARY.

It is immaterial whether the discovery of mineral in the ground claimed and located is made before or after the marking of its boundaries, and the performance of such acts, where recording notice of the location is not required, perfects the location. Hence the fact that a locator on discovering that his boundaries exceeded the amount of ground to which he was entitled, changed one of the lines so as to exclude such excess and in so doing, he excluded the hole in which he made his discovery; but this did not vitiate his entire claim, provided he made another discovery within the boundaries as changed before any right in the premises had been acquired by another.

Waskey *v.* Hammer, 170 Fed. 31, May, 1909.

EXCESSIVE LOCATION OF MINE.

An excessive mineral location made in good faith, and conforming otherwise to the legal requirements, is not wholly void but invalid as to the excessive area only. And in such case, the locator may select the portion of the claim he will reject as such excess.

Waskey *v.* Hammer, 170 Fed. 31, May, 1909.

LOCATION OF MINE—QUALIFICATION OF LOCATOR.

The United States statutes prevented the officers, clerks and employes of the general land office from purchasing or becoming interested in the purchase of any public lands. But where a person while competent to make a mineral location, did locate a mine with an excessive area, and thereafter changed the boundaries of his claim so as to exclude the point of discovery, and before making a new discovery within the readjusted boundaries, was appointed a deputy surveyor of the Land Department, his claim perfected by a new discovery after his appointment was void.

Waskey *v.* Hammer, 170 Fed. 31, May, 1909.

LOCATION OF MINING CLAIM.

Under the United States statutes possessory title to a mining claim can only be acquired by a valid location. An essential of possessory title to a mining claim is the discovery of minerals thereon. Where the locators of two associated claims, which overlapped, were sinking shafts at the same time, the first to discover mineral has priority of right, although the location was staked after the other, if made openly and peaceably.

Hanson *v.* Craig, 170 Fed. 62, May, 1909.

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Location of Placer Mining Claim.

Mining claims are not opened to relocation until the rights of a former locator have come to an end, and two locations cannot legally occupy the same space at the same time. In the location of placer mines, the surface is the thing located, and the position of the surface is absolutely essential to the mining operation. A valid mining location although unpatented, is a grant and the estate enjoyed is in the nature of an estate in fee, and it is an appropriation of land by the locator to the exclusion of all others. There is no reason why a junior locator of a placer claim cannot lay his lines across a claim already located. But the rule is that an association placer mining claim cannot be located over other prior claims so as to include within its boundaries and to appropriate a number of unlocated and non-contiguous fractions lying between such prior claim.

Stengfeld *v.* Espe, 171 Fed. 825, May, 1909.

Mining Locations—Adverse Claims.

The United States statutes which provide for the prosecution of adverse claims to mining locations, are said to apply only to adverse claims arising out of independent or conflicting locations of the same ground; they do not apply to controversies between co-owners claiming under the same location.

Allen *v.* Blanche Gold Min. Co., (Colo.) 102 Pac. 1072, July, 1909.

Validity of Mining Claim.

A valid mining claim can only be based upon a discovery within the limits of the claim, and the existence of mineral in such quantities as to render the land more valuable for mining than for any other purpose, and the minerals discovered should be such and in sufficient quantities as to justify a prudent man in the expenditure of time and money in the exploration and development of the claim.

Golden *v.* Murphy, (Nev.) 103 Pac. 394, July, 1909.

Mining Claim—Right to Follow Vein or Lode.

The general rule is that a location may be sustained by the discovery of mineral deposits of such value as to at least justify the exploration by a prudent person of the lode in the expectation of finding ore sufficiently valuable to work. But while the filling of a vein or lode must consist of a body of mineral or mineral bearing rock, yet what value such material should contain is not devoid of difficulty, but is one to which no standard of value can be stated applicable to all cases. However, such value must necessarily depend upon the characteristics of the district or country in which the vein or lode is located, and upon the character, as to the boundaries of the vein itself. If the country rock, or the general mass of the mountain outside of the limits of the vein, is found to be wholly barren, then slight values of the vein material would be sufficient to satisfy the law; or if on the other hand,

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the rock of the district generally carries value, then undoubtedly the values in the vein material, where the boundaries of the vein are not well defined, either on the surface or at any depth, should be in excess of those of the surrounding rock, otherwise there can be no line of demarkation, and where the rock is generally broken, shattered, fissured there would be nothing to separate it from the adjacent country. The law is, therefore, that values of the filling of a vein, must be considered with special reference to the district where the vein or lode is found. And even the definition of a lode must always have special reference to the formation and peculiar characteristics of the particular district in which the lode or vein is found.

Golden *v.* Murphy, (Nev.) 103 Pac. 394, July, 1909.

Boundaries of Mining Claim—Meaning of "About."

In describing the boundaries of a mining claim and in giving distance of the lines by the use of the word "about" in connection with a certain given distance is meant that the given distance is not to be taken with exact precision, but that established corners and monuments are intended to control the actual distance stated. And in case of doubt as to boundary lines, monuments and lines actually marked and capable of identification control courses and distances.

Bullion-Beck & Champion Min. Co. *v.* Eureka Hill Min. Co., (Utah) 103 Pac. 881, August, 1909.

Action for Possession of Mining Claim—Variance in Description.

Where mining claims were marked out on the ground and the boundaries well known to a person attempting to relocate the property, his entry was on territory plainly defined in the different locations; and in an action for possession a variance between the description of the complainant's claim in an amended notice of location, from the description pleaded in the complaint and contained in the original notice was not a fatal defect under a statute declaring that no variance is to be material unless it shall have actually misled the adverse party to his prejudice. And the defect was immaterial where the defendant was not misled by the variance in the description of the plaintiff's claims between that contained in an amended notice of location and that stated in his complaint.

National Mill & Min. Co. v. Piccolo, (Wash.) 104 Pac. 128, September, 1909.

Relocation of Mining Claim.

A relocation of a forfeited mining claim was held to be invalid in the absence of proof that the relocator had sunk a shaft on the claim, and that his relocation certificate stated that a part or the whole was located as abandoned property,—a mere marking on the ground and posting notice proper for an original location being insufficient; nor was the obligation to sink a shaft excused by the statute which pro-

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vided that the provisions relating to discovery shafts should not apply to locations west of the summit of the Cascade Mountains. There can be no relocation on a mere temporary abandonment and where there had been at all times a bona fide intent on the first locator's part to return to the unpatented mining claims in controversy and renew the work of developing them at the time of the attempt to relocate them.

National Mill & Min. Co. *v.* Piccolo, (Wash.) 104 Pac. 128, September, 1909.

CONFLICTING RIGHTS.

Presumption as to Ownership of Minerals.

The presumption that an owner of the surface of a mining claim owns all minerals beneath it ceases when it is shown that a vein found beneath the surface has its apex in a claim belonging to another person. But the burden of proving ownership of such apex vein and its dip and descent to and underneath another claim, in order to overcome the presumptive ownership of the surface owner, is on the person who asserts ownership of such apex vein.

Keely *v.* Ophir Hill Consolidated Min. Co., 169 Fed. 601, April, 1909.

Mining Claim—Adverse Possession.

A possessor's right to ground covered by a mining claim, regardless of whether or not it was subject to location as a mining claim, may be supported by adverse possession alone. And such possession would give all ledges or veins apexing within the boundaries of the claim, and the right to follow them within his side lines extended vertically downward. Whether or not such adverse possession would carry with it extralateral rights, in the event the ground passed to a town-site for town-site purposes under a patent seems never to have been passed upon and settled and the supreme court of Nevada declined to pass upon the question, where the validity of a location could be determined without passing upon that particular question. But if the claim in question never passed under a town-site patent, then the locator is entitled to any extralateral rights which he may have established by the evidence. And the rule is that a valid and subsisting mining claim on land covered by a town-site patent at the time the patent was issued does not pass thereunder, nor is the title or right of possession affected thereby under the United States statute declaring that no title shall be asquired to any mine of gold, silver, cinnabar or copper, or to any valid mining claim or possession held under existing laws.

Golden *v.* Murphy, (Nev.) 103 Pac. 394, July, 1909.

Trespass on Mining Claims—Time for Bringing Action.

Under a statute providing that actions for trespass on mining claims and mines must be brought within three years from the time the action accrues, but providing that when a trespass is committed by under-

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ground workings on any mining claim, the cause of action shall not accrue until the discovery of the trespass, it was decided by the supreme court of Utah that an action for trespass brought eight years after the ore was removed from the mine was not barred by the statute where it was shown that the plaintiff did not have actual knowledge of the trespass prior to six months before the bringing of his action and that accordingly the action was not barred.

Bullion-Beck & Champion Min. Co. *v.* Eureka Hill Min. Co., (Utah) 103 Pac. 881, August, 1909.

Forfeiture and Abandonment of Mining Claims.

The rule that the plaintiff must recover in a possessory action on the strength of his own title, and not on the weakness of his adversary, does not apply in actions to recover unpatented mining claims. In such an action the question to be determined is: Which as against the other, has the better right to the mining claim in controversy? Where a forfeiture is charged, there is no question of intent; the only question is whether the law has been complied with. An abandonment may occur at any time before the issue of patent, while forfeiture properly speaking can only occur at stated statutory periods upon failure to perform the annual representation. A forfeiture is never complete until adverse claims are made to the property under other locations, while abandonment operates at once. In such a controversy, the claimant who has spent a large sum of money on a mining location in a good faith endeavor to develop it into a mine, unquestionably has a superior right to the property over one who enters with the sole purpose of appropriating to himself the fruits of the foresight and labor of the first occupant. And the locator who had temporarily left the claim in controversy, but at all times intended in good faith to return and take up the work, was held to have a superior title to one who entered without right in his absence and attempted to appropriate his labors and effects.

National Mill & Min. Co. *v.* Piccolo, (Wash.) 104 Pac. 128, September, 1909.

MINING LEASES.

Lease of Minerals—Construction.

A land owner leased to another the right and privilege of prospecting for coal, oil or other minerals, and the right to dig, excavate and bore for the same, and to remove them if found in paying quantities. Oil had been discovered in the vicinity and two wells had been put down on the premises, and the existence of coal was well known. Some of the wells dug produced oil in paying quantities, and the additional compensation was paid and the prospecting was continued for several years, but fifteen years after the execution of the lease, the premises were abandoned. No mines were opened for coal and no use was made of the premises except for the purpose of prospecting and

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pumping oil. After the premises were conveyed, subject to such lease, in a controversy between the lessee and the grantee, it was held to be a lease for oil, gas and salt purposes, and not a deed conveying, in fee simple, the minerals under the land.

McMillin *v.* Titus, (Pa.) 72 Atl. 240, January, 1909.

LEASE OF MINES—WHEN IRREVOCABLE.

A lease or license to operate a mine under the Wisconsin statute regulating mining, is irrevocable after a valuable discovery or prospect has been struck; but if the miner shall forfeit his rights by negligence such as establishes a forfeiture according to mining usages, then the lessor may revoke it notwithstanding a valuable discovery or a prospect has been struck. This rule permits revocation after discovery for a particular cause, but whether or not the cause exists is to be determined by proof of mining usages. However, the statute provides other causes for forfeiture after discovery, such as concealing or disposing of ores or minerals, or concealing or disposing of "mines or diggings" for the purpose of defrauding the lessor of his rent, or neglect for three days after notice and claim of rent to pay rent on ores or minerals "raised" by the lessee or licensee.

St. Anthony Min. & Milling Co. *v.* Shaffra, (Wis.) 129 N.W. 238, March, 1909.

MINING LEASE—SIGNIFICANCE OF "CREVICE" OR "RANGE."

The word "range" as applied to mineral deposits is commonly understood to designate a large stretch of country, often many miles in length and of considerable width, carrying with some continuity or at intervals ore deposits belonging generally to the same geological stratum. A "crevice" is a word some times applied to a mineral-bearing vein; but under the Wisconsin statute the words "crevice" or "range" had a local significance limiting the word "range" by its associated word "crevice," and taken together they were not intended to designate a large stretch of country carrying with some continuity, or at intervals, ore deposits and belonging generally to the same geological stratum.

St. Anthony Min. & Milling Co. *v.* Shaffra, (Wis.) 129 N.W. 238, March, 1909.

LEASE OF MINE—DISCOVERY—REVOCATION.

A miner operating under a license from a lessor, terminable at his will, in case of the discovery of a prospect, may continue his exploration free from the lessor's right to revoke the lease before the prospect has been sufficiently explored to determine whether it will lead to a a discovery or not, and in case of a discovered vein or crevice to entitle the miner to follow the deposit within the lines of the leased premises lengthwise, sidewise, and downward, on paying the current royalty to the lessor.

St. Anthony Min. & Milling Co. *v.* Shaffra, (Wis.) 129 N.W. 238, March, 1909.

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MINING—DISCOVERY.

The development and uncovering of a mineral deposit in a known mineral-bearing lode, and alongside of old workings which existed long prior to the inception of the lease, did not constitute "discovery" within the meaning of a statute which provided that the discovery of a "crevice" or "range" (see definition above) containing ores should entitle the discoverer to follow it until it was exhausted, free from the right of the landlord to forfeit the lease.

St. Anthony Min. & Milling Co. *v.* Shaffra, (Wis.) 129 N.W. 238, March, 1909.

OIL AND GAS LEASE—CONSTRUCTION.

The discovery of oil or gas under a lease giving the right of exploration and production, in the absence of anything showing a contrary intention, is sufficient to create a vested estate in the lessee of the exclusive right to produce oil or gas; but the right may be lost by abandonment, by failure to produce oil or gas, or to pursue the work of production, or development of the property. But the right will not be lost merely because the lessee continued to drill deeper in search of oil or gas in a lower sand, and oil or gas was not found in such lower sand within the limitation described by the lease.

Eastern Oil Co. *v.* Coulehan, (W. Va.) 64 S. E. 836, April, 1909.

MINING LEASE OR LICENSE.

A contract simply giving a right to take ore from a mine, where no estate is granted, confers a mere license, and the licensee acquires no right to the ore until separated from the land. But an instrument demising lands for the sole purpose of mining and operating for ore, gas and other minerals, laying pipe lines, building tanks, and structures to take care of the products, and for a designated term of years at a fixed rental, is a lease conveying an interest in the land and more than a mere license to enter. And such lessee may maintain ejectment against a third person who claimed adversely to the lessor.

Barnsdall *v.* Bradford Gas Co., (Pa.) 74 Atlantic 207, June, 1909.

GAS AND OIL LEASE—CONSTRUCTION.

A lease granted to the lessee the right to produce oil and gas from certain lands for ten years with the exclusive right to drill and operate oil and gas wells, to lay and operate pipe lines, with the necessary right of way over the premises, and a sufficient quantity of lands to preserve the products, and that when oil or gas should be found in paying products the lessor would extend the lease from year to year so long as such production continued and limited the lessee's use to so much of the land as might be necessary for the purposes named. In a controversy over the lease as to the exclusive use of the land, the lease was construed to give no general or exclusive right to lay and operate pipe lines, but only sufficient rights in that respect to enable the lessee to carry out the main object of producing and removing oil

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and gas, and that a subsequent permission by the lessor to a third person to construct a pipe line across such leased land to conduct oil from other lands to market was not adverse to the rights of the lessee in the land, until the lessee began to use the part of the land through which the leased pipe line ran and until his use of that part of the land became incompatible with the maintenance of the other pipe line.

Brookshire Oil Co. *v.* Casmalia Ranch Oil & Dev. Co., (Cal.) 103 Pac. 927, August, 1909.

ASSESSMENT WORK.

Mining Claim—Failure to Perform Representation Work—Forfeiture.

Where a forfeiture of a mining claim is based on the theory that the claimant failed to perform the necessary representation work, the burden of proof is on the person setting up such forfeiture to establish the same by clear and convincing proof. But where a forfeiture is sought for failure to do such representation work, and the locator contends that certain work done by him on one of a group of claims was done in fact for the benefit of the entire group, the burden of proof then shifts to the locator and he is required to prove that the work was adapted to and suitable for the development of all the claims, and that it was intended for that purpose. This rule was applied where it was claimed that the work of extending a tunnel for the purpose of intercepting a vein appearing in a shaft which had theretofore been sunk on a certain claim from the top of a hill, but such tunnel was on the opposite side of a gulch from all the other claims in controversy, and it did not appear that the vein sought to be intercepted traversed in all the other claims, or even crossed the gulch in their direction; and in order to render the tunnel available to develop any of the other claims it would be necessary to sink a shaft or winze to a depth below the level of the gulch, and to drift toward such tunnel many hundred feet, and to carry out this plan would be far more expensive than by sinking a shaft in the gulch in connection with the other claims in the group. Under such circumstances it was decided by the supreme court of Montana that the representation work in the way of extending the tunnel was not reasonably adapted to, and could not in good faith have been intended to, develop the claims on the other side of the gulch, and such work was not sufficient to prevent a forfeiture of such claims.

Copper Mountain Mining & Smelting Co. *v.* Butte & Corbin Consolidated Copper & Silver Mining Co., (Mont.) 104 Pacific 540, October, 1909.

Mining Claim—Improvement Work.

The annual expenditure required by the United States statute to preserve the title to mining claims may be made in work or improvements within the boundaries of the claims themselves, or upon one of a group of contiguous claims or upon adjacent patented lands, or even

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upon adjacent public lands, provided however that such work or improvements are made for the purpose of developing the claims and to facilitate the extraction of mineral therefrom. The rule of law in such cases is that the labor and improvements are deemed to have been made upon a mining claim, whether it consists of one or several locations, when such labor is performed or improvements made for the development of the claim, and to facilitate the extraction of the metals therefrom, though such labor and improvements may in fact be on ground which originally constituted only one of the locations, as in sinking a shaft on one of such claims; or the labor improvements may be at a distance from the claim itself, such as labor necessary for the turning of a stream or the introduction of water into the mine; or where such improvements consist in the construction of a flume to carry off the debris or waste material from the mine and its operation. The law recognizes the absurdity, for instance, of requiring a shaft to be sunk on each location in a consolidated claim, when one shaft would suffice for all the locations. However, if the work done on one of several claims has no reference to the other claims of a group, or if it does not tend to develop all in conformity with a general plan, then the rule stated does not apply.

Copper Mountain Mining & Smelting Co. *v.* Butte & Corbin Consolidated Copper & Silver Mining Co., (Mont.) 104 Pacific 540, October, 1909.

LIABILITY OF INJURY TO MINER.

Injury to Miner—Negligence in Storing Explosives.

The negligence of a mine owner in storing dynamite in dangerous quantities, where its accidental explosion would necessarily endanger the lives of the employes, was held to be the proximate cause of injury to a miner by the explosion of the dynamite, though the source of the spark exploding it was accidental and unknown.

Brown *v.* West Riverside Coal Co., (Iowa) 120 N. W. 732, April, 1909.

Miner—Assumption of Risk.

A miner assumes the risks incident to the service, and where the service involves the use of explosives, he takes on himself the risk of all injuries to which he may be exposed by their reasonable use; but he does not assume any risk created by the negligence of the owner of the mine, unless he knows and appreciates, or, as a reasonable person ought to know and appreciate, the peril arising from the negligence and chooses to remain in the service.

Brown *v.* West Riverside Coal Co., (Iowa) 120 N. W. 732, April, 1909.

Injury to Miner—Fellow Servant.

The owner and operator of a mine cannot be held liable for the mistake or incompetency of the certified foreman required by the statute of Pennsylvania, where the statute invests such foreman with

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power to compel compliance with his directions, so far as they relate to the safety of employes. And the supreme court of Pennsylvania has just decided that a mine foreman is a fellow-servant with the other mine employes of the same employer engaged in a common business, and the employer is not liable for injury due to the negligence of such foreman. But it is not clear whether the court referred to the negligence of the foreman required by the statute called a "certified foreman," or an ordinary foreman employed by the operator of the mine.

Golden *v.* Mt. Jessup Coal Co., (Pa.) 73 Atl. 1103, June, 1909.

Injury to Miner—Negligence.

Where a miner, a boy of fifteen years of age, was struck by a runaway car and badly injured, it was claimed that the mining company was negligent for not furnishing an ambulance to take him promptly to a place for proper treatment. The proof showed that after the injury the boy was left in the engine house for half an hour, was then placed on a stretcher with two quilts placed over him, and carried by workmen one mile to his home; that the weather was cold and sleety, and that during the journey the covering over the boy became wet and cold. There was some evidence to show that the boy died as the consequences of the shock and from the result of exposure and accident. The court refused to decide as a matter of law that the mining company was liable for negligence for failing to provide an ambulance at its mines as required by the statute of Pennsylvania, by which the boy might have been promptly and carefully removed after the injury; but a jury under the facts submitted and the proper instructions of the court found that the company was guilty of negligence.

Lenahan *v.* Crescent Coal Mining Co., (Pa.) 74 Atlantic 58, June, 1909.

Injury to Miner—Contributory Negligence.

A mule driven by a miner hauling coal out of a mine, by reason of an accumulation of damp or foul air in the mine suddenly slowed up, and the driver to avoid being caught between the mule and the car jumped from his position and was injured. In an action for damages for the injury, on the ground of negligence of the mine owner, it was ruled by the supreme court of Iowa that his failure to properly sprag the car was not contributory negligence, it not being necessarily the proximate cause of the injury. And it was further ruled that whether the injured miner has assumed the risk incident to changed conditions in the ventilation of the mine was a question of fact to be determined by the jury.

Hodges *v.* Colfax Consolidated Coal Co., (Iowa) 122 Northwestern 908, October, 1909.

COAL LANDS.

Burning Mine not a Nuisance.

A mine within the limits of a city and which was being consumed by fire that had existed for two or three years, and was beyond the

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control of the lessee which had expended its entire capital stock in an effort to extinguish the fire, was held not such a nuisance that the lessee could be ordered to abate. The lessee in such case could at most only be compelled to use its corporate assets and funds in an effort to put out the fire, and this having been done, a court of equity would not compel it to do any more.

McCabe *v.* Watt, (Pa.) 73 Atl. 453, March, 1909.

Right of Life Tenant to Work or Lease Mine.

The rule that it is not waste of the estate for a life tenant to work a mine opened in the life time of the testator, even to exhaustion, has its limitations, and cannot be unduly and unreasonably extended. Thus the rule did not include the right to lease coal underlying a tract of land adjacent to a homestead farm on which a coal mine had been opened in the life time of the testator, and which adjacent tract was undeveloped mineral lands. The life tenant could not lease and receive the royalty from such undeveloped mineral lands to the exclusion of the remainderman.

McFadden's Estate, In re, (Pa.) 73 Atl. 927, April, 1909.

Coal or Mineral Lands.

Lands containing coal are held to be "mineral lands" within the meaning of that term as generally employed in the laws regulating the disposition of the public domain. And it has been the general policy of the government to reserve mineral lands from grants of the public lands.

United States *v.* Northern Pac. R. Co., 170 Fed. 498, April, 1909.

Mining Lease—Recovery of Minimum Rental.

A lease of a coal mine provided that the lessee should not be required to pay the minimum rental but continue mining operations where the coal was less than two feet and a half in general thickness. In an action by the lessor for the minimum rental, the supreme court of Pennsylvania said that the burden was on the lessee to prove that the coal was of less thickness than two feet and a half, and where the evidence was conflicting, and tended to show that the lessee had not made proper examinations to test the actual thickness, the lessor was permitted to recover.

Holt *v.* Kelley, (Pa.) 73 Atl. 947, May, 1909.

Operation of Coal Mine—Surface Support.

The owner and operator of a coal mine, where the ownership of the minerals is severed from the ownership of the surface, must leave sufficient natural or artificial support to sustain the surface in the operation of the mines. Any failure to properly support the surface will render the mine owner liable for injury caused to the surface by such failure, irrespective of the question of negligence.

Paull *v.* Island Coal Co., (Ind.) 88 N.E. 859, June, 1909.

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OPERATION OF COAL MINE—SUPPORT OF SURFACE—WAIVER.

Where a deed by which mineral rights were conveyed to another stated that it was mutually agreed that the grantee should not be responsible for injury to the surface resulting from removing the minerals, the grantor thereby waived his right to recover damages for injury to the surface caused by operating the mine. The implied right of the surface owner to support does not alone determine the rights of the parties; but the instrument by which the conveyance of the minerals is made controls where it makes definite provisions as to the rights of the parties.

Paull *v.* Island Coal Co., (Ind.) 88 N.E. 859, June, 1909.

TAXATION OF COAL LANDS.

In ascertaining the valuation for taxation of coal lands under the assessment laws of Pennsylvania, the superficial, and not the foot-acre, is the unit of value. The law requires that the valuation of a tract of land for the purpose of taxation shall be ascertained and determined upon the basis of the market value or the selling price. In many instances the foot-acre rule would work a hardship and be unjust. This is true when applied to the bituminous coal fields where in the lower productive measures there are five different veins of coal, some of these veins having great commercial value, while others have very little, and others are practically worthless for present use; and the coal in the different veins differs in grade and quality. Hence the foot-acre basis would not apply. The foot-acre basis of ascertaining assessable values is not of general application, and when applied to coal lands, the local conditions must be such as to give the whole coal area a present market value which can be ascertained upon some definite fixed basis. In such cases the assessment officer or the court must determine the assessable value of lands from the best testimony available.

Lehigh & Wilkes-Barre Company's Assessment, In re, (Pa.) 74 Atlantic 65, June, 1909.

COAL LEASE—RECOVERY OF ROYALTIES.

Under a coal lease which provided for payment of royalties on two sizes of coal only, the smaller of which was pea coal, the lessor was not entitled to recover any royalties on the smaller sizes known as buckwheat, rice and barley. And under such a lease the lessee could not be charged for use of gangways on the premises for transporting coal from other properties leased or worked by him.

New York & Pittston Coal Co. *v.* Hillside Coal & Iron Co., (Pa.) 74 Atlantic 26, June, 1909.

ENFORCEMENT OF AGREEMENT TO EXECUTE LEASE FOR MINE.

The owner of lands containing coal mines made an oral agreement with a third person to lease such lands and mines for a long term of

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years, the lessee to work and mine such lands and mines continuously, in good faith and in miner-like manner. Under the oral agreement the lessee took possession and for three years faithfully carried out the terms of the oral lease. He installed machinery, erected improvements, sunk shafts, and ran drifts at an expenditure of $30,000, and until the property became valuable. After all this work and on repeated demands the lessor refused to execute a lease for the period of time agreed upon. In an action by the lessee to secure his rights and protect his investment, the lessor was compelled to perform his part of the oral agreement, and to execute a lease for the required period.

Zellenken *v.* Lynch, (Kans.) 104 Pacific 563, October, 1909.

MISCELLANEOUS.

Flooding Mine—Damages.

A corporation drilling a well on its own land but near a mine drilled through sandstone into a shale that lies above the slate which served as a roof immediately over the coal in the plaintiff's mine, and the loose shale permitted the water to pass through it down to the slate and to weaken the strength of the covering of the mine so that it fell and caused the mine to be flooded. It was charged that the company drilling the well knew the subterranean formations in that locality, and that if it drilled the well as it did, injuries would result to the mine. It was also charged that after the well had been drilled and the water began to flow from it into the mine the company made no effort to prevent it. In an action for damages, the court left it to the jury under proper instructions to determine whether the defendant in drilling the well should have had such knowledge of the character of the strata as would lead it to believe that the water might flow from the well into the mine; and that if such was the character of the strata, and the fact was of common notoriety, the company would be chargeable with such knowledge, and under the instructions and the facts, a judgment for the plaintiff for the damages was sustained.

Muntz *v.* Cottage Hill Land Co., (Pa.) 72 Atl. 247, January, 1909.

Deed Reserving Minerals—Effect.

A deed conveying land but reserving to the grantor all the clay, fire-clay and other minerals, severs such minerals in ownership from the land and creates two estates therein; and the grantee, the purchaser of the surface, can not obstruct the mineral owner from the use of the surface for ingress and egress and methods of transportation fairly useful and necessary.

Porter *v.* Mack Mfg. Co., (W. Va.) 64 S. E. 853, May, 1909.

Conveyance of Mining Land.

A deed purporting to convey "all minerals underlying the land described," was held not to be a conveyance of the natural gas there-

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under, where, taken in connection with all the evidence, it appeared that the parties did not intend a conveyance of the gas.

McKinney *v.* Central Kentucky Natural Gas Co., (Ky.) 120 S. E. 314, June, 1909.

MACHINERY FOR DRILLING OIL AND GAS WELL NOT A FIXTURE.

Machinery placed on lands leased for gas and oil purposes does not become a permanent fixture nor part of the freehold because of such annexation to the land as was necessary to develop the premises according to the terms of the lease; and even on a forfeiture of such lease, such machinery does not vest in the lessor. But where such a lease authorized the lessor to remove the fixtures at any time, the right was said not to be unlimited as to time, but the lessee was only entitled to remove such machinery within a reasonable time after the expiration of the lease.

Perry *v.* Acme Oil Co., (Ind.) 88 N. E. 859, June, 1909.

OIL AND GAS LEASE—FORFEITURE.

An oil and gas lease provided for drilling and operating oil and gas wells, and on failure to do so, the lessee was to pay an agreed sum per day to the lessor for such failure or delay; and on failure to drill, operate or to pay the agreed sum, the lease should be void. In an action that involved the forfeiture of the lease and the respective rights of the parties, it was decided that the provision that the lease should be void was for the benefit of the lessor, and that on a breach of the lease he might declare and receive forfeiture by proper notice, or waive the forfeiture and proceed against the lessee for failure to perform the covenants of the lease and that the title did not revest in the lessor immediately on the lessee's default.

Perry *v.* Acme Oil Co., (Ind.) 88 N. E. 859, June, 1909.

MINING—RELATIVE RIGHTS OF MINE AND SURFACE OWNERS.

The right of a mine owner to take minerals underneath the surface is subordinate to the right of the owner of the soil or of the surface to have it supported in its natural position; this right is a part of the freehold, and the mining must be exercised in such a way as not to deprive the owner of the soil of his existing rights. Under such circumstances the mine owner cannot establish a custom of allowing miners to destroy the surface support by removing the pillars, as such a custom would be void.

Southwest Missouri R. Co. *v.* Big Three Min. Co., (Mo.) 119, S. W. 982, June, 1909.

OIL AND GAS LEASE—VESTED ESTATE.

The interest of a lessee in oil and gas under a lease by which oil and gas in certain described premises are granted to him with the right of entry for drilling purposes becomes vested on the discovery of oil and gas.

Ramage *v.* Wilson, (Ind.) 88 N. E. 862, June, 1909.

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Easement in Connection with Mining Claim.

A conveyance to a mining company owning claims of the perpetual right to use adjoining tracts of land for a shaft and for dumping ground was held to be an easement, and that the improvements placed thereon in the working of the claims, together with the tracts of land constituted appurtenances to the mine and claims.

Park City Meat Co. *v.* Silver Min. Co., (Utah) 103 Pac. 254, June, 1909.

Mining—Partnership.

A mining partnership may be formed by an ordinary partnership agreement, or by the operation of a mine by some of the joint owners with the consent or acquiescence of the other joint owners. And where such a partnership existed, the conveyance by one joint owner of his interest in the mine to a stranger did not dissolve the partnership in its operation, and the grantee became a partner in the place of the grantor, who then ceased to be a member of the firm.

Loy *v.* Alston, 172 Fed. 90, July, 1909.

Historical Sketch of Nevada Mining Claims.

A very interesting historical sketch of the origin of the rules of mining and of such early mining claims in Nevada as the Comstock and Canyon claims has recently been given by the supreme court of Nevada. The court suggested that it could properly take judicial notice of the fact that the particular property in controversy was in the region of the earliest discoveries of gold in that state, the region whose history is part and parcel of the history of the Comstock lode, which in turn was a part of the history of the government, of such importance as to merit recordation, as long as the nation, which the Comstock helped so effectually to maintain, should last. To this region, from 1859 and until after the 70's the miners from the "diggins" of California, adventurous spirits from all parts of the nation and the world gathered and a large portion of the country was located in accordance with the customs and rules of the miners before the passage of any laws regulating such locations. The court pays a tribute to that distinguished lawyer, statesman and citizen, Hon. William M. Stewart, under whose leadership was enacted by Congress in 1866 the first legislation upon the subject. The distinguished senator, advocating the passage of the act, spoke in high praise of the regulations and customs of miners and portrayed in glowing language the wonderful results that had followed the system of free mining, which had prevailed with the tacit consent of the government. He stated that the legislature of California had wisely declared that the rules and regulations of miners should be received in evidence in all controversies respecting mining claims, and when not in conflict with the constitution or laws of the state or the United States, should govern their determination, and that a series of wise judicial decisions had moulded these regulations and customs into "a comprehensive system of common law, embracing not only mining law broadly speaking, but also

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regulating the use of water for mining purposes." He declared that the miner's law was a part of the miner's nature; that he had made it and he trusted it and obeyed it; that he had given the honest toil of his life to discover wealth which when found was protected by no higher law than that enacted by himself under the implied sanction of a just and generous government. He also stated that the proposed act continued the system of free mining; holding the mineral lands opened to exploration and occupation subject to legislation by Congress and local rules; that it merely recognized the obligation of the government to respect private rights which had grown up under its tacit consent and approval, and that it proposed no new system, but sanctioned, regulated and confirmed a system already established, to which the people were attached. The court said that while these statements of the author of the act in securing its adoption could not control its construction, in case of doubt yet they did show the condition of mining property on the public lands of the United States, and the tenure by which it was held and controlled by miners in the absence of legislation, and that they thus served to indicate the probable intention of Congress in the passage of the act.

Golden *v.* Murphy, (Nev.) 103 Pac. 394, July, 1909.

Nature of Natural Gas as Property.

A state has not the right to survey and preserve by law natural gas found within its territorial limits as a thing in which the people of the state have a common interest; but a single person who by lawful right reduces natural gas to possession has the absolute right of property therein, and may transport and sell and deliver the same as other personal property, and the state cannot deprive him of this right without just compensation, and any statute attempting to do this is a violation of the Fourteenth Amendment of the Federal Constitution.

Kansas Natural Gas Co. *v.* Haskell, 172 Fed. 545, July, 1909.

Fraud in Sale of Mine—Cancellation of Contract.

An option contract to purchase certain mining property could not be rescinded on the ground of fraud because of erroneous statements made by the seller as to the quantity of ore produced on the property, where the purchasers were to take possession of and operate the property for several months before the option expired; and where it appeared that the statements were made in good faith and expressed the honest opinion of the seller, who had little knowledge of practical mining.

Winter *v.* Bostwick, 172 Fed. 285, August, 1909.

Conveyance of Minerals.

A deed conveying without reserve all the iron ore under the land described to the grantee and his heirs and assigns forever, without any suggestion that the title should in any event revert to the grantor, was

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sufficient to pass a fee simple to the ore and not merely a license to operate the mine.

Morrison *v.* American Assn., (Va.) 65 S. E. 469, September, 1909.

Ownership of Surface and Minerals.

It is a well-settled principle of mining law that one person may own the surface and another the minerals in the same land. It is also the rule that title to the freehold of either the surface or minerals thereunder cannot be acquired by adverse possession of the other.

Morrison *v.* American Assn., (Va.) 65 S. E. 469, September, 1909.

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UNIVERSITY NOTES.

Readers of the QUARTERLY will have learned with regret of the resignations of Professor Chandler and Professor Van Amringe, and with gratification of the cordially appreciative resolutions passed by the trustees in providing for their release from the active duties of teaching. In a subsequent issue we hope to present sketches of the careers of these distinguished professors whose long and devoted services and commanding personalities have played such a prominent part in the history of the School of Mines.

Among the many public lectures on engineering, industrial and Schools of Mines, Engineering and Chemistry it is interesting to note that members of the Department of Mechanical Engineering have been invited to lecture to the members of the National Association of Stationary Engineers which is composed of men who operate the power plants in the large hotels, apartment houses and manufacturing establishments throughout the metropolitan district. These lectures are being delivered without charge and with the sole idea of performing a public service and increasing the scientific knowledge and efficiency of the operating engineers throughout our city and in that way help them to operate their plants more economically for their employers. The lecturers and their subjects are as follows:

Professor Rautenstrauch, "Valve Gears," January 29, 145 East 58th St.

Professor Rautenstrauch, "Valve Gears," February 11, 92d St. and 3d Ave.

Mr. Parr, "Plant Measurements," March 5, 2126 Broadway.

Mr. Parr, "Plant Measurements," March 19, 148th St. and Willis Ave.

Professor Lucke, "Mechanical Refrigeration," April 2, 209 West 54th St.

Professor Lucke, "Mechanical Refrigeration," April 16, 67th St. and 3d Ave.

The lectures are creating a great deal of interest among engineers who are attending them.

DEPARTMENT OF GEOLOGY.

As soon as the final examinations in May were over the officers of the department went with the third year School of Mines students and with some also from the college and the graduate schools, to Potts-

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ville, Pa. Making this city of the southern anthracite basin headquarters the quadrangle which has been topographically mapped by the U. S. Geological Survey as the Pottsville sheet, was covered by the party during the week which could be devoted to field-work. The region is one of more than ordinary structural interest. Eight or ten well-marked geological formations are admirably exposed and are folded in a series of parallel and curving outcrops which gave excellent opportunities for study. The party, numbering about seventy succeeded in completing the map and also in seeing something of anthracite mining. Many courtesies were extended by the good people of Pottsville, more especially by Mr. Baird Halberstadt, formerly of the Pennsylvania Geological Survey.

The month of June was especially employed by Professor Kemp, in finishing for the N. Y. State Geological Survey a bulletin upon the Geology of the Port Henry and Elizabethtown quadrangles of the eastern Adirondacks. This region embraces the great iron mines at Mineville, near Port Henry and also the old colonial fortresses on Crown Point, in one of the first settlements in the then wilderness of the early part of the eighteenth century. Some added interest accrues to the bulletin because of the historical celebrations the past summer of the early discovery of Lake Champlain. It is hoped that the bulletin may appear before the year closes. Early in July Professor Kemp went to the lead-silver district of the Cœur d'Alenes, Idaho, and spent six weeks at Wardner. On the way home ten days were passed with Reno H. Sales, '00 S., chief geologist of the Amalgamated Copper Co. in the mines of Butte, Mont.

The Eleventh International Geological Congress will be held in August, 1910, in Stockholm, Sweden. The committee in charge is making a special feature of a volume which will treat of the iron-ore reserves of the various countries of the world having important deposits. At the request of the committee in charge, Professor Kemp has prepared the articles upon the United States and its outlying possessions; upon the West Indies, Central America and parts of South America. Outside of Cuba, however, but little is known of important iron ores in the West Indies, and information regarding Central America and much of South America is most meager.

During the Easter holidays, Professor Grabau conducted a party of seven graduate students through a section of the Appalachians in southern Pennsylvania. The object of the trip which was taken in connection with the course in the Comparative Geology of North America was to study the upper Ordovicic and Siluric formations, which were recently reclassified by Professor Grabau and to gain further light on the question of origin of their formations. The party started at Tyrone, Pa., studying the sections in Bald Eagle Mt., and thence on foot, and occasionally by train, proceeded along the Little Juniata, etc., to the Susquehanna at Harrisburg, studying all the available sections and making extensive collections. Material for several papers has been secured.

In the summer session, Professor Grabau conducted three classes—

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S1, General Geology, 1 lecture and 1 laboratory hour a day with field work on Saturdays, attendance 25; S15, Elementary Palæontology, 1 lecture and 1 laboratory hour per day, attendance 7, and S151, Principles of Geology, 1 lecture a day with additional work for graduate students, attendance 11, mostly of graduate students. On Saturdays field trips to various localities about New York were made, including one all-day excursion to the Cretacic section of the Atlantic Highlands. The assistants in the summer session this year were Miss Moon and Miss Morris, graduate students of the department. Mr. Rogers also assisted in the field work.

At the end of the summer session, a party of eleven of the students spent three days at Becraft Mountain near Hudson, N. Y., studying the stratigraphy and structure of this outlier under the guidance of Professor Grabau, and collecting fossils. At the end of this time, half of the party went to the Catskills to study the upper Devonic, while the others accompanied Professor Grabau to Boston where a day was spent in the study of the intricate structure and the stratigraphy of Nahant, and another in the study of the origin of Nantasket Beach, the volcanics of Allerton and the glacial Lake Bouvé, described by Crosby and Grabau. A short time was also spent at the interesting Cambric ledges at Weymouth, where the Etcheminian fauna was discovered some years ago.

Before and after the summer session, Professor Grabau was occupied in the completion of the book on "North American Index Fossils," which he is issuing in collaboration with Professor H. W. Shimer (Ph.D., 07) of the Massachusetts Institute of Technology. The first volume—823 pages, exclusive of index, and with 1,210 text figures—is now published. The second volume of about the same size is in type.

At the Baltimore meeting of the American Association for the Advancement of Science, Professor Grabau took part by request in the symposium on correlation, the part assigned being the physical and faunal evolution of North America during Ordovicic, Siluric and Early Devonic Time. This has since been published in the *Journal of Geology*. Another paper by Messrs. Lane, Prosser, Sherzer and Grabau, on the "Nomenclature and Subdivision of the Upper Siluric Strata of Michigan, Ohio and Western New York," has appeared and one by Sherzer and Grabau, on a "New Upper Siluric Fauna from Southern Michigan." At Baltimore, Professor Grabau presented a paper on "New or Little Used Geologic Terms," Section E, and one on the "Tertiary Drainage in Central Western New York," before the Geological Society of America.

Dr. Berkey continued work for the N. Y. State Geological Survey and kept in touch with the progress of explorations which are being made by the City of New York in connection with the new water supply. A bulletin is in preparation summarizing the results of these investigations. The data gathered add materially to the knowledge of the details of geologic structure at many points in southeastern New York. This is especially true of certain portions of Manhattan Island.

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Short trips were made into Connecticut and Virginia in connection with other problems.

Jesse E. Hyde, assistant in the department, served as assistant geologist on the Geological Survey of Ohio during the months of February, March and April, 1909, and was engaged in the study of collections from the Waverly formations of Ohio. The months of May, June, July, August and September were largely devoted to field work on the same formations in southern and central Ohio, and to the physiography of the area covered.

Miss Elvira Wood, curator in palæontology, and candidate for the Ph.D. degree, has continued her study of the phylogeny of the genus Cerithium begun in September, 1908. During the winter of 1908–9 and the summer of 1909, collections at the American Museum of Natural History, The Boston Society of Natural History, and the Museum of Comparative Zoology, Cambridge, Mass., were studied. The libraries of these institutions also furnished valuable aid. The investigation will be continued at the University palæontological laboratory during the coming winter.

D. D. Condit, scholar in geology, served as Assistant Geologist on the Geological Survey of Ohio during the months of June, July, August and a portion of September. He was engaged in mapping the No. 8 (Pittsburg) and No. 9 (Meigs Creek) Coal seams of Ohio.

Early in July, F. K. Morris, candidate for the A.M. degree, spent two weeks in western New York, continuing work commenced last summer. The work, mainly palæontological, was a detailed study of the Hamilton shales and limestone, exposed in the bed of Morse's Creek, at Athol Springs, some ten miles south of Buffalo. Each recognizable bed was charted and a collection of its fauna secured. About four hundred pounds of material was shipped to be added to that collected last summer.

During the rest of the summer Mr. Morris was engaged upon an investigation of the fauna of the Michigan Hamilton. Material was supplied by Dr. Grabau, and the work was designed to assist Dr. Grabau in his larger study of the geology and palæontology of the Traverse region of Michigan.

A special study of the genus *Stropheodonta* was started in connection with this work, and this is now nearly complete.

Mr. P. Billingsley, candidate Ph.D., spent several weeks in the spring and fall in the Shawangunk Mts. of Ulster Co., N. Y., and the Kittatiny Mountains, their prolongation into New Jersey. The historic sections in Pennsylvania, where the Susquehanna, Schuylkill, Lehigh and Delaware Rivers cut the range, were also visited. The hard conglomerates and sandstones that form these mountains vary greatly in character and thickness. It is hoped, therefore, that the measurements made in the field, and the material collected from many sections can be coördinated in such a way as to cast some light on the origin of these formations, and the paleogeographic conditions under which they were deposited.

In the summer months a field party, consisting of Messrs. Barrows,

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Martin and Billingsley (all graduate students in the department), was located on Manitoulin Island, Lake Huron, and the mainland to the north. They obtained measurements and fossils from the Paleozoic rocks on the island, with a view to their more accurate correlation. Some time was also spent in leveling and mapping the oil region about Gou Bay, Ont., where the well records have much stratigraphic value. On the north shore the party worked in the Huronian and Laurentian rocks. As a result of the summer's work, in which nearly 800 miles were covered by boat and canoe, material has been collected from the entire geologic column found in the region studied.

The work of other graduate students was continued during the summer, viz., Miss E. Long, in the phylogeny of Turbo; Miss M. Morris, on some Crag Mollusca from England; Miss E. Moon, on the ontogeny of *Platytrochus*, a Tertiary coral.

The Ph.D. dissertation of Thomas Brown, "Studies on the Morphology and Development of Certain Rugose Coral," was published by the New York Academy of Sciences. Dr. Brown has been appointed professor of geology in Middlebury College, Vermont. And the A.M. thesis of Miss Wood, "A Critical Summary of Troosts," unpublished manuscript on the crinoids of Tennessee, was published by the Smithsonian Institution.

The department has received the gift of an extensive collection of recent shells and other invertebrates from Dr. Geo. A. Ferguson, '90S, the collection having been made by his father. It will be of great value in the research work on the phylogeny of the mollusca carried on in the department and for purposes of comparison. The collection is now being installed in Room 104 S. A gift of a valuable collection of the Tertiary species of *Planorbis* from Steinheim, Würtemberg, has also been received from Oberfürster Gottschick, of Steinheim, through the mediation of Mr. Erich Goede, a friend of the department. This is one of the few collections of this famous series of shells in this country. Much material has also been added to the palæontological museum by collections made during the year.

J. F. KEMP.

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BOOK REVIEWS.

Heat Energy and Fuels. Von HANNS VON JÜPTNER. Translated by O. Nagel. New York, McGraw Publishing Co. 306 pp. $3.00.

Of the four volumes of Professor von Jüptner covering the study of chemical engineering from the view of forms of energy, Dr. Nagel has translated the first dealing with Heat Energy and Fuels, part 1, Heat Measurement, Combustion and Fuels. In twenty-three chapters we have the following titles: The Measurement of High Temperatures; Pyrometry; Optical Methods of Measuring Temperatures; Combustion Heat and its Determination; Direct Methods for Determining the Combustion Heat; Incomplete Combustion; Combustion Temperature; Fuels; Wood; Fossil Solid Fuels; Peat; Brown Coal; Bituminous and Anthracite Coals; Artificial Solid Fuels; Charcoal; Peat-Coal, Coke and Briquettes; Coking Apparatus; Liquid Fuels; Gaseous Fuels; Producer Gas; Water Gas; Dowson Gas; Blast-Furnace Gas and Regenerated Combustion Gases; Apparatus for Production of Fuel Gases. The general reader will find the book of great interest and clearly written, though at times the aid of calculus is necessary. For the student however there are some important omissions. For example, under the heading of pyrometry a cut showing the Wanner pyrometer and a description of the Holborn-Kurlbaum pyrometer might replace some of the descriptions of the older and out-of-date instruments. Again under Calorimetry the Fisher, the Mahler and the Parr instruments alone are given as the examples of those most widely used. The same is true of the section on Apparatus for the Production of Fuel Gases.

W. C.

Metallografia Applicata ai Prodotti Siderurgici. UMBERTO SAVOIA. Milan, Ulrico Hoepli. xiii + 208 p., ill.

The book is divided into fifteen chapters, each followed by a short bibliography. Historical; Preparation of Specimen; Microscope; Metallographic Examination; Iron and its Alloys; Constituents of Iron-Carbon Alloys; Equilibrium Diagram; Microstructure of Iron; Microstructure of Steel; Carbon Steels; Ternary Steels; Quaternary Steels; Cast Iron; Malleable Cast Iron; Study of a Steel Hardened at One End.

The work follows along the same general lines as Osmond's "General Method for the Micrographic Analysis of Carbon Steels," though of course the illustrations are much inferior. The repetition of the same illustrations seems a waste; Figs. 6, 11 and 24 are the same, Fig. 16 the same as Fig. 32, in all six cuts are repeated. The Roozeboom diagram is given and ought to have been accompanied by those of more recent date.

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As an elementary introduction to the study of the structure of iron and steel, this book will probably serve to fill a want in Italian iron and steel metallurgy.

W. CAMPBELL.

North American Index Fossils. Invertebrates. By AMADEUS W. GRABAU, and HERVEY WOODBURN SHIMER. New York, A. G. Seiler and Co., 1899. Vol. I., $6.

This work, whose opening pages appeared in the SCHOOL OF MINES QUARTERLY two years ago, has grown into two volumes, of which the first is now issued. The second will shortly follow. The work was suggested by the need of a text-book based on American examples and dealing with those fossils which are specially used in the identification of strata. The work has grown beyond the size originally contemplated, but the authors found themselves constantly confronted by the problem of accepting or rejecting species which on the whole they felt might be later indispensable to some worker in the field. The general decision has been to embrace and enlarge, rather than run the risk of omitting and regretting.

The present volume deals with the lower forms protozoons, corals and molluscs, besides others less frequently met. The molluscs are the fossils which are on the whole most commonly used, and of them the brachiopods are the ones most frequently employed as guides in the older strata. Volume II. will take up the cephalopods, so important in the Mesozoic times, the worms, the crustaceans and the insects.

The work is profusely illustrated. Every species has its picture from two or more points of view. There are abundant, analytical keys scattered through the pages to aid in the determination of species. Under each species is given a brief summary of its characteristics and the geological horizon in which it is found. A field worker with only a rudimentary acquaintance with paleontology can run his fossils down quite closely by means of the pictures. It is the hope and ambition of the authors that it will be found useful by engineers called to little studied American localities as well as by special students of paleontology. Yet with the scope of the work, it amounts also to a manual of this branch of science, but one based on the American forms. Some idea of the extent of the ground covered may be gained from the fact that Volume I. has 823 pages. It contains descriptions of 744 genera, embracing 2,163 species. There are 1,210 cuts with a total of 3,431 figures. Volume II. will treat of fewer genera, 524, and fewer species, 1,259. There are 737 cuts with 1,891 figures.

The work is of special interest to Columbia men, since Dr. Grabau, the senior author, is professor of paleontology, and Dr. Shimer, the junior author, now assistant professor of paleontology in the Massachusetts Institute of Technology, took his Ph.D. at Columbia and was formerly assistant in the department of geology.

J. F. K.

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THE

SCHOOL OF MINES QUARTERLY.

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ENGINEERING PROFESSIONS.*

BY BENJAMIN B. LAWRENCE.

Engineering professions were originally but two, namely, civil and military engineering.

Military engineering had to do with war and the engines of war, while civil engineering, as its name implies, dealt with the gentler things having to do with man's welfare.

These two professions have now become subdivided, and our universities give degrees in civil, mining, mechanical and electrical engineering.

Of these, civil may be called the elder brother, and electrical the younger. Each profession must dovetail into the other, so that it is difficult to differentiate as between them—where the business or duty of the civil engineer ends and where that of the mechanical engineer begins.

Civil engineering covers railroads and public works.

Mechanical engineering has to do with the mechanics of both professions.

Electrical engineering deals with that still mysterious force which has revolutionized them all; and

* Owing to the unavoidable absence of Mr. W. B. Parsons, who was to deliver a lecture on this subject—Mr. Lawrence was asked to take his place. Having but a few hours in which to prepare himself he resorted to the expeedient of applying to two other engineers to give their views, while he was putting his own in shape. What follows recommends itself not as studied effort, but rather as being (as Mr. Lawrence expressed it in his remarks) ideas "hot from the griddle." (Delivered at Columbia University Chapel, March 8, 1910.)

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Mining engineering covers the development, equipment and operation of mines.

Civil Engineering.

[At this point Mr. Lawrence read from notes given him by Eugene Klapp, Civil Engineer.]

Civil engineering, which is the oldest branch of the profession, and which some authorities claim to be an all-embracing designation, including military, mining, electrical, bridge, hydraulic and all other forms of the engineering profession, has lately come to be restricted almost entirely to the planning and construction of fixed structures, such as dams, bridges, canals and railroads.

You must in a measure meet new conditions. In modern industrial life the civil engineer must be something very much more than a scientist. His college education is merely a tool with which his work is to be done. It is his shovel and his pick, but without the man back of the shovel and pick little can be accomplished. A good mechanical draughtsman, a good instrument man and good mathematical calculator has the possession of a trade and in its highest sense nothing more. The successful civil engineer must employ these trades either himself or supervise the employment of them by others to accomplish some great end, but he must look always to the end and not at the tools. He must be more than merely a follower, an employee, to carry out the conceptions of other men, he must have conceptions of his own; he must have imagination to see that in a certain place a railroad will pay or will serve some great public good. He must have imagination to see that a certain river, if bridged, would add greatly to the material or general welfare of the community; imagination to see that foundations can be constructed and judgment sufficiently trained to know that the construction can be done within a reasonable cost of time and money. He must train himself to know men, to know their weaknesses and their idiosyncracies and the means by which they can be pursuaded to lend their energies to his guiding hand, to the end that a certain great purpose may be accomplished.

Any of you who go forth into the world as civil engineers must first of all make up your minds that while serving in your first

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subordinate position your main problem is to correlate your own talents and abilities to those of your associates. Step by step you must learn how to get along with your fellow workmen; how to get along with the laborers with whom you come in contact; how to deal most successfully and fairly with the contractors who may be placed under your supervision, and if you do not fully realize that only by a skillful manipulation of the human elements with which you come in contact can you possibly finally reach the upper grades of the profession, you will never go much farther than the prosecution of your trade, be it a draughtsmanship, instrument work or calculations.

All engineers, but especially civil engineers, may well study the activities of the legal profession to realize how the possession of a trained mind, using the tools of a trade—that is, knowledge of the law—has enabled lawyers to push their way to the upper branches of most of the industrial and transportation enterprises of the country, and to realize that this success is the result of their not being satisfied with merely answering questions as to the intent of the law, nor getting a man out of jail when he has broken some fundamental law of the land, but is, rather, the result of the constant use of their knowledge of the law to aid and direct the policy of their clients.

With a great industrial age well started, civil engineers who are almost entirely associated with great public works, transportation companies and municipal and governmental projects, are in an ideal position to assume similar leadership in the conduct of affairs. But you must raise your eyes to the sky, and not continue to keep them bent upon the muck-rake in your hand. You must train your imagination to a broad outlook, must take an interest in public affairs, in the trend of legislation and public sentiment and cultivate yourself to become a broad-minded citizen of the world, and not merely a carpenter working at his bench, with no thought beyond the piece of work directly beneath his hand.

Mechanical Engineering

[Here Mr. Lawrence read from his own manuscript.]

Mechanical engineering stands to all of the professions of engineering as one of the chief foundation stones upon which success

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must be built. A thorough groundwork in mechanics seems to be necessary in these days to carry on any large engineering work.

The great manufacturing concerns of the United States have by their energy and foresight seen the wisdom of employing mechanical engineers in all departments of their work. These business concerns have in their employ the leading mechanical engineers in this country, and it is through the labors of these men that the United States stands at the head in mechanical devices for doing the great things which modern engineering requires.

Quantity, and still greater quantity, and again more, is the cry of the producer. From the cornfields of the West, where mechanics now play such a large part in the gathering of the harvest to the great iron and copper mines of the country, quantity is the cry, and the mechanical engineer has responded by providing the equipment demanded by these conditions.

Mechanical engineering, therefore, is growing in importance, and no man desirous of entering any of the engineering professions should neglect this subject.

Electrical Engineering.

[At this point Mr. Lawrence read from notes prepared by Dr. Cary T. Hutchinson, Electrical Engineer.]

The youngest branch of the science of engineering, electrical engineering, bids fair to become the most important of all. Beginning one hundred years ago, in the crudest form, with the engineering of systems of communication, that is the telegraph, it has grown from this to embrace the field of telephony, the business of transportation, the production of power on a large scale, and its transmission, and it may now be said to be that branch of engineering that unites all others. It touches civil engineering in its application to heavy railroad work and in practically all kinds of transportation, as well as its application in communication. It touches mining engineering in the various applications of hoisting machinery, explosives and the generation, transmission and utilization of power. Mechanical engineering may be regarded as its principal assistant, in that all manifestations of electrical energy are brought about by means of mechanical devices.

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Not only is electrical engineering intimately related to the other branches of engineering, but a study and knowledge of it presupposes a broad knowledge of physics, chemistry and mathematics, and of the inter-relations between physics, chemistry and electricity. In its scope it is probably the broadest of the several branches of engineering.

MINING ENGINEERING.

[Here Mr. Lawrence read from his own notes.]

Probably the most polyglot of all the professions is that of mining engineering—geologist, surveyor, lawyer, mechanic, chemist, metallurgist, mineralogist, electrician, this was the mining engineer of the old school. Specialization naturally followed growth in the profession. Mining engineering had to be specialized in order that your well-equipped man should not become swamped in the multitude of its requirements.

The first division in the profession has been the evolution of the metallurgist; so that mining engineering is now divorced from metallurgy in that the mining engineer is not expected to be a metallurgist in the sense of knowing how to treat his product after he gets it above ground. The treatment of ores by milling and concentration has grown into a profession of itself, and the chemist and metallurgist have joined hands in making the profession of metallurgy one that is now recognized in the business world.

To my mind, the mining engineer's chief concern should be in producing the ore from the earth at the least possible cost, having in mind the preservation of the property as a workable mine. This is enough ground for the well-equipped mining engineer to cover. The development of mines, their proper timbering and ventilating, the use of tools underground, are enormous subjects, worthy to be made the life study of any one man.

The handling and treatment of the ore after it is mined should be the work of the mechanical engineer and the metallurgist.

Geology, has done, and is doing, so much to point the way for the miner, that ultimately the consulting geologist will take his place as a distinct factor in the more practical professions.

In addition to these requirements must be the cultivation of a certain facility of expression and good manners. The engineering professions should be followed by gentlemen.

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MINERALS FROM THE PEGMATITE VEINS OF RINCON, SAN DIEGO CO., CALIFORNIA.

By AUSTIN F. ROGERS.

During a trip to San Diego Co., California, the writer collected a suite of minerals from the pegmatite veins at Rincon, in the northern part of the county on the San Luis Rey River. It was through the courtesy of Mr. C. J. Moore, of Palo Alto, that the writer was able to collect these interesting specimens.

There are three principal veins on which claims have been located and on which a certain amount of quarrying for gems has been done. These are named the Victor, the Rincon and the Mack. The veins vary in width from three to ten feet and have a dip of 40 to 50° toward the west or southwest. The veins are granite-pegmatites and consist principally of quartz, orthoclase and muscovite, which are arranged in bands parallel to the walls of the vein. The bands are due to variation in the coarseness of the grain as well as to the presence of certain minerals. Along the median line of the vein are lens-shaped pockets which contain the lithium-bearing and associated minerals for which San Diego Co. is so famous. The pegmatite on the Victor claim has the greatest variety of minerals and is the most interesting for study.

The main points of this paper are the descriptions of bismite (found for the first time in crystals), pleonaste, cookeite and zeolites which have never been described from this district before, the description of a unique type of lepidotite crystals and the paragenesis of minerals in the Victor pegmatite vein.

Description of the Minerals.

Bismuth in small, bright metallic cleavages occurs in the lepidotite of the Victor vein.

Bismite is associated with the bismuth as a bright yellow oxidation product. For the most part it consists of irregular particles, but several minute crystals (Fig. 1) were found with the microscope. The tabular crystals lie on the 100 face and are terminated

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by 011 faces. The angle (011 ∧ 01$\bar{1}$) is 94°, the recorded value being 93° 34′. The crystals have parallel extinction, elongation parallel to the slower ray and the interference colors are often the abnormal Berlin blue. Natural crystals of bismite have not previously been described but our crystals agree with the description of the artificial Bi_2O_3.*

Quartz.—Crystals from this locality have been described by Waring.† Most of the crystals are singly terminated, about 1 cm. in diameter and 2 or 3 cm. in length. The principal forms are 10$\bar{1}$1, 0111, 10$\bar{1}$0, 11$\bar{2}$1 and 51$\bar{6}$1.

Twin crystals with 10$\bar{1}$0 as twinning plane are common. Small doubly terminated opaque white crystals of long prismatic habit occur in cavities and probably represent a second generation of quartz.

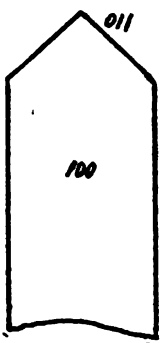

FIG. 1.

Hyalite occurs as a secondary mineral, forming a thin coating on some of the quartz crystals and albite crystals. It is glassy, transparent with botryoidal surface and is very brittle. In fragments the hyalite shows very weak double refraction and some of them give an imperfect spherulitic black cross which means that the brittle character is due to strain.

Spinel.—The iron-bearing spinel, pleonaste, is found in two of the veins at Rincon in small (.25 mm.) crystals associated with small garnet crystals. A few imperfect octahedra were isolated. In fragments the mineral is perfectly isotropic, deep green in color, and its index of refraction is greater than that of methylene iodide which distinguishes it from other varieties of spinel. Blue spinel has been reported‡ from Rincon but was not found by the writer.

Orthoclase is a prominent constituent of the veins, but is rarely well crystallized. Several imperfect, somewhat distorted crystals are rather tabular, parallel to 010 and elongated in direction of the *c*-axis. The forms observed are 001, 010, 100, 110, 130, $\bar{1}$01, $\bar{2}$01 and $\bar{1}$11. A few Baveno twins were found.

Most of the orthoclase at this locality is perthite, an intergrowth

* Groth, "Chemische Kristallographie," part 1, p. 109.

† *Am. Jour. Sci.* (4), 20, 125, 1905.

‡ Bull. 37, Cal. State Min. Bureau, p. 48, 1905.

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of orthoclase with thin plates of polysynthetically twinned albite usually approximately parallel to the 100 face. The orthoclase is clear and weathers away easily, leaving ridges of albite which is more opaque. These corroded specimens are often covered with a secondary parallel growth of clear, glassy orthoclase. In one specimen this secondary orthoclase had a narrow 100 face.

In a pale brown perthite specimen the plates of albite are set parallel to the 110 face.

Microcline.—Part of this pale brown feldspar is microcline. The hand specimen shows a checked appearance on the basal cleavage. A thin section exhibits the characteristic twinning of microcline. This microcline-perthite has albite lamellae inserted parallel to 100 and also parallel to 110 as the angle between the traces of 100 and 110 on 001 measures 34° as against the theoretical angle of 33° 22′, which is $\tan^{-1}$ 0.6585 (à axis of orthoclase). This specimen shows incipient alteration along the cracks between microcline and albite.

Albite is a prominent mineral of the veins. At the Victor mine it occurs in crystals of the usual habit, tabular parallel to 010, about 1 mm. thick and about 1 cm. in the direction of the *c*-axis. The forms are 010, 001, 110, 1$\bar{1}$0, $\bar{1}$30, 130, 101, 201, 1$\bar{1}$1 and $\bar{1}\bar{1}$1. The forms 001 and $\bar{1}$01 are usually in equal combination. The crystals are invariably twinned, usually according to both the albite and Carlsbad laws. A single albite twin and a single Carlsbad twin were observed. The compound twins are of two kinds: (1) Two halves of a crystal are twinned according to the Carlsbad law and each of these has polysynthetic twins according to the albite law; (2) an albite twin has a small crystal tacked on one side and united according to the Carlsbad law.

At the Rincon mine the albite occurs in sub-parallel aggregates which are comparatively thick in the direction of the *b*-axis and have very short 110 faces, thus approaching the pericline habit. The crystals are albite twins with the forms mentioned above.

Spodumene.—The Kunzite variety of spodumene occurs in the clay pockets at the Victor mine and some gem material has been obtained. The crystals in habit and appearance resemble those described by Schaller* from Pala, but are more perfect, though

* Bull. Dept. Geol. Univ. of Cal., 3, 265, 1903.

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smaller and paler in color. The habit is tabular to 100; 110 is prominent, and 010 usually narrow. The prisms 320 and 130 were noted on several crystals. A few crystals show terminal forms 021 and $\bar{1}11$. The new form 111 was observed on one crystal (Fig. 4).

Kunz,* who first described this mineral, mentions twinning as a prominent feature, while Schaller† says that his crystals showed no evidences of twinning. Among the Rincon crystals, however, are many undoubted twins. The evidence for twinning is based

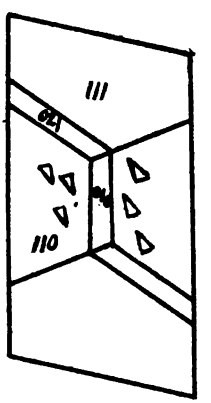

FIG. 2.

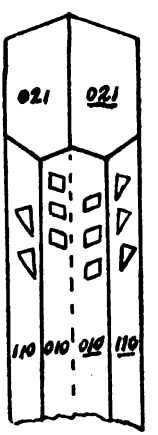

FIG. 3.

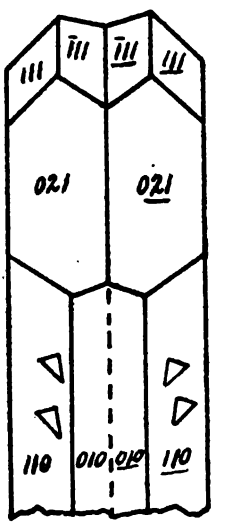

FIG. 4.

upon an examination of the natural etch-figures, which are so characteristic of the unit prism faces. The etch-figures are triangular in form and agree exactly with the description given by Schaller. The acute angle of the etch-figure on the front 110 face points downward. In an untwinned crystal the acute angle on the back $\bar{1}10$ face points upward (Fig. 2) while in a twinned crystal (100 being the twin-plane) the acute angle on the back face $\bar{1}10$ points downward (Figs. 3 and 4). Fig. 2 is an untwinned crystal with 021 as the dominant terminal form.

Fig. 3 represents a twinned crystal in which the twinning is

* *Am. Jour. Sci.* (4), 16, 264, 1903.

† *Loc. cit.*

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apparent from an inspection of the etch-figures on 010 as well as those on 110. Fig. 4 is a twinned crystal with the new form, which was established by contact goniometer measurements ranging from 48° to 51°, the calculated value being 50° 36′. Fig. 5 is a sketch of a prism face with etch-figures. The right half is a $1\bar{1}0$ face while the left half is a 110 face in twinning position to it. These two faces are in one plane on account of twinning.

Beryl.—At Rincon beryl occurs in several varieties. Ordinary greenish subtranslucent crystals of prismatic habit up to 10 cm. in length have been found. Aquamarine crystals of slender prismatic habit usually small and often needle-like have been found

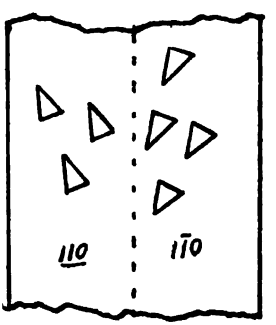

FIG. 5.

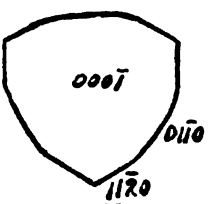

FIG. 6a.

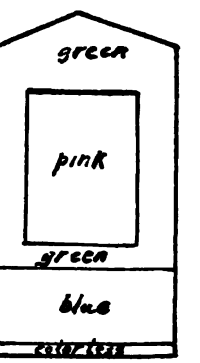

FIG. 6b.

in the Rincon mine as well as a few magnificent clear sea-green crystals of gem quality about 5 cm. long. The aquamarine crystals are usually terminated by 10$\bar{1}$1, 11$\bar{2}$1 and 0001, the latter face being very brilliant. The prism faces include 21$\bar{3}$0 in addition to 1010. A typical crystal has been figured by Ford.* A few transparent pale pink beryls of thick tabular habit were found at the Victor mine. One crystal measured 18 mm. by 25 mm. and had small faces of 11$\bar{2}$1 and 21$\bar{3}$1 in addition to the dominant forms, 1011 and 10$\bar{1}$0.

Garnet.—In the so-called line-rock (granulite) there are minute red garnet crystals .25 mm. in diameter arranged in parallel bands. The trapezohedron 211 is the dominant form modified by the dodecahedron. A soft plumose muscovite near the Victor mine contains 1 cm. garnet crystals with 110 and 211, the former dominant.

* *Am. Jour. Sci.* (4), 22, 217, 1906.

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Epidote occurs as a secondary mineral in seams associated with black tourmaline.

Tourmaline.—At Rincon tourmaline occurs in a variety of colors—pink, blue, violet, green, colorless and black. The black tourmaline is found all through the pegmatites, but the colored varieties are confined to the pockets of the Victor vein. Only one habit of crystals was observed. Prismatic crystals of rounded triangular cross-section due to oscillatory combination of $11\bar{2}0$ and $01\bar{1}0$ with sometimes $10\bar{1}0$ as a line face are terminated at one end by the ditrigonal pyramid $12\bar{3}2$ (Fig. 6, *a*) and the trigonal pyramid $10\bar{1}1$, and at the other end by the pedion $000\bar{1}$ and often by small faces of the trigonal pyramid $01\bar{1}1$ (Fig. 6, *c*). The distribution

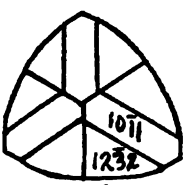

FIG. 6*c*.

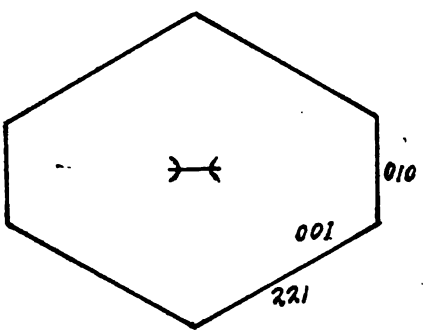

FIG. 7.

of color in these tourmalines is usually as given in Fig. 6, *b*. The central part is pink. Surrounding that on all sides is a pale green zone. The lower part of the crystal is deep blue often with a pale blue or colorless layer at the extreme end. A crystal broken transversely through the middle shows a central pink core with a green exterior zone. But some crystals are practically all blue or green, while others are mostly pink. Minute colorless prismatic crystals (achroite) occurring as a coating on quartz, albite and lepidolite probably represents a secondary deposit of tourmaline. A little rubellite in radiating columnar aggregates occurs in lepidolite as in the Stewart mine at Pala.

Stilbite.—At the Victor mine stilbite occurs as brown sheaf-like aggregates coating all the other minerals of the pockets. The individual crystals are 3 or 4 mm. long and have a rectangular cross-section with an apparent rhombic pyramidal termination.

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Heulandite occurs sparingly associated with stilbite. The crystals are pale brown, sharp in angle and have the usual forms 010, 001, 201, $\bar{2}01$ and 110.

The zeolites are apparently very rare in granite-pegmatites, the only other locality known to the writer being San Piero, Elba.*

Laumontite.—Minute crystals of the common habit (110 and $\bar{2}01$) were found on a few specimens as a cavity lining. A very soft radiated white mineral from the Victor is apparently a laumontite pseudomorph after stilbite.

Muscovite.—The muscovite crystals found at the Mack mine are interesting because they have terminal faces and are often twinned. They are found in cavities which are lined with albite crystals and are often coated with red clay. The crystals are tabular, six-sided in outline, some being pseudohexagonal but most of them are somewhat elongated in the direction of the *b*-axis. They usually measure 2 to 3 cm. in diameter. The forms are 001, 010 and 221, the angle 001 $\wedge$ 010 being 90° and the angle 001 $\wedge$ 221 being 85° 36′ (meas. 86°). Fig. 7 represents a typical crystal with side elevation showing the monoclinic symmetry. On 001 the crystals show smaller parallel growths. Crystals are twinned according to the mica law. The twins are apparently made up of overlapping plates in twinning position. But such is not the case, for the composition face is perpendicular to the plates. The axial plane is normal to 010 and one arm of the percussion figure is parallel to 010. $2E$ for Na light was found to be 69° 26′.

Some large muscovite cleavages from the Victor mine are like Fig. 8, the longer striations representing gliding planes parallel to 205 and the shorter ones, gliding planes parallel to 135. In cross-section these cleavages are wedge-shaped.

Lepidolite occurs at the Victor mine near the center of the vein, but is not very prominent. It is fine to coarse scaly and is often intimately associated with albite crystals.

Two kinds of crystals are noted: (1) Pseudo-hexagonal crystals of tabular habit, (2) pseudo-rhombic crystals of prismatic habit united by twinning to form stellate groups. The pseudo-hexagonal tabular crystals are usually twins, but a single crystal is represented in Fig. 9. Here the forms are 001, 131, 100 and 010. The angle 010 $\wedge$ $\bar{1}31$ was found to be 29½°, the calculated being 30° 22′.

* Dana, "System of Mineralogy," 6 ed., 585, 1892.

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The axial plane is parallel to 010, so it is a mica of the second class. Figure 11 is a crystal twinned according to the mica law, 001 being the composition face. In another type of twin, the crystal is made

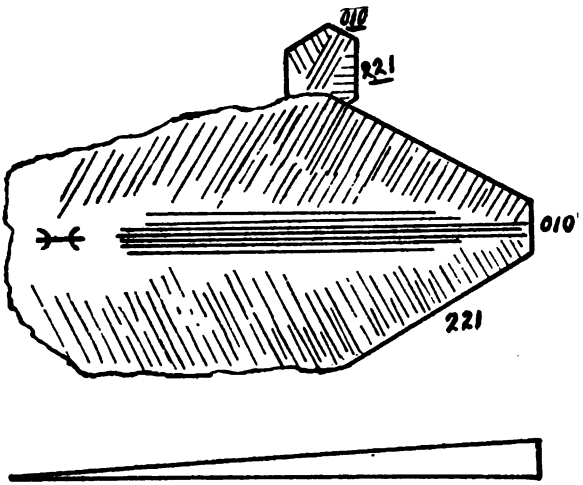

FIG. 8.

up of three individuals (Fig. 10) the composition face being perpendicular to 001.

Unique crystals of lepidolite are represented by Figs. 12*a*, and 12*b*. The habit is determined by $\bar{1}31$. The axial plane as well as the plane of symmetry is parallel to the long diagonal. Single crystals of this type occur, but they are rare. Most of the crystals

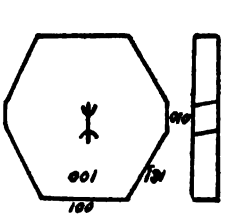

FIG. 9.

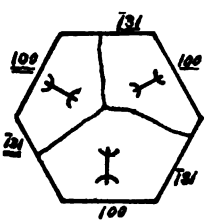

FIG. 10.

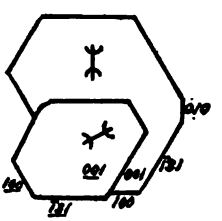

FIG. 11.

are twinned groups, according to the mica law. They consist of six single crystals. Examination of these crystals shows that they have as a common base a single cleavage, which, examined in polarized light, shows six rather confused sectors extinguishing in opposite parallel pairs. The obliquity of the $\bar{1}31$ faces to the base

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is the reason that there are spaces between the upper parts of the crystals. This fact is brought out in Fig. 12*b*, which is an elevation of the two opposite crystals which have their *a*-axes horizontal.

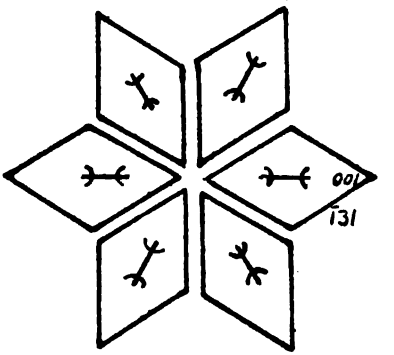

FIG. 12*a*.

These crystals often have 010 faces present, also 100 faces and occasionally both 010 and 100 are present.

Biotite was found in the Victor mine as thin dark brown inelastic cleavable plates about 3 cm. in diameter.

Cookeite.—This mineral occurs in the pegmatite veins of Maine and Connecticut, but is here described for the first time from San

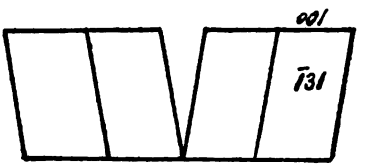

FIG. 12*b*.

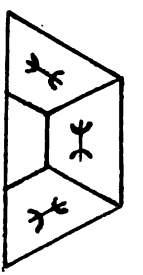

FIG. 13.

Diego Co. It was found in the pockets at the Victor mine coating quartz, lepidolite, orthoclase, albite and kunzite, and as the matrix of kunzite. It is clearly a secondary mineral—a pseudomorph of cookeite after kunzite was found. Cookeite is a micaceous mineral occurring in minute rosettes (not over 1 mm.) or in massive aggregates. The color varies from colorless to deep pink, a yellowish-

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pink being very common. The blowpipe tests agree with those given for cookeite in Dana's "System." The soda fusion is bluish-green, indicating manganese. The crystals are half-hexagonal in outline and if complete would be made up of a central unaxial core with six biaxial sectors as in Fig. 13. The axial plane of the sectors is parallel to the hexagonal outline and the axial angle is rather small. This agrees with the description given by Penfield.*

Columbite.—Several small imperfect prismatic crystals were found in the Victor mine. The forms are 100, 210, 130, 103 and 133. There is distinct cleavage parallel to 100.

Amblygonite.—A few small specimens of white cleavable amblygonite were found at the Victor mine.

Apatite.—Pale dirty green thin to thick tabular crystals of apatite were found at a prospect near the Victor. The forms are 0001, $10\bar{1}0$, $11\bar{2}1$, $10\bar{1}2$, $10\bar{1}1$ and $31\bar{4}1$.

Paragenesis of the Minerals of the Victor Vein.

With the exception of the zeolites the minerals are all characteristic species of granite-pegmatites. The minerals occur for the most part in lens-shaped pockets along the median line of the vein. According to Brögger and Harker the work of mineralizers in the formation of pegmatites is both constructive and destructive in nature. Orthoclase, albite, quartz, tourmaline (colored) and lepidolite form the walls of the pockets. They were probably formed simultaneously, for when two of them occur together it is almost impossible to tell which was formed first. The crystallization of these minerals probably represents the end of the constructive period. Many of the pockets contain clay. The above mentioned minerals are often coated with cookeite and zeolites. Besides the orthoclase crystals are often corroded. These results are probably due to destructive action of the mineralizers occasioned by fall in temperature. The kunzite is almost invariably found embedded in the clay of the pockets, but it hardly seems reasonable to regard it as a secondary mineral. One specimen in the University collection shows a kunzite crystal firmly attached to a lepidolite-albite matrix, projecting out in what was a cavity. The presence of kunzite in the clay is perhaps due to the fact that the crystals were attacked

* *Am. Jour. Sci.* (3), 45, 393, 1893.

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by mineralizers on all sides and so fell from the walls into the bottom of the pockets. The kunzite crystals are usually much corroded and rounded. The pocket clay was probably formed from the feldspars and the cookeite, clearly a secondary mineral, may have been formed from either tourmaline, lepidolite or kunzite. The cookeite is often the matrix of kunzite and also of tourmaline. The zeolites were formed after the cookeite, perhaps by solutions at temperature little above the ordinary, after the gases were given off. Finally the hyalite was the last mineral to form as it occurs on stilbite in one specimen. It was formed from ordinary solutions as its presence on a freshly broken rock surface would indicate.

One specimen illustrating the above paragenesis deserves description. In the bottom of a pocket there was found just below a large quartz crystal a thin crust of the same outline which had evidently fallen from it. The inside smooth surface of this crust was pink cookeite, while the outside was stilbite. A few isolated sti - crystals were also found inside the crust. Several crystals of very much corroded kunzite were firmly embedded in the crust and penetrated the inside surface.

STANFORD UNIVERSITY, CALIF.,
October, 1909.

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FOUNDATIONS FOR THE NORTHWESTERN RAILWAY TERMINAL BUILDING, CHICAGO.

By MAURICE DEUTSCH, C.E.

In the construction of high buildings in Chicago, engineers are often confronted with very difficult foundation problems which can be undertaken and solved only by men who have had experience under similar conditions. In the construction of the foundations for the Terminal Building for the Chicago and Northwestern Railway Co., the work was carried on by the contractors according to the customary "Chicago method," up to a depth of about 80 feet below the street. At this point, such difficulties were encountered that the method had to be abandoned for the remaining depth to rock (which varied from 114 to 120 feet below curb). This part of the work (excavating 87 piers from an elevation of about 80 feet to about 120 feet below curb) was entrusted to The Foundation Company, who applied the "pneumatic process" with success.

The first 10 to 15 feet below curb level was a filling of refuse material of various kinds deposited there after the Chicago fire. Down to the hardpan, which was encountered at a level varying from 70 to 75 feet below curb, there was a bed of heavy blue clay which was quite plastic at the top but increases in stiffness with the depth. The hardpan varied from 10 to 20 feet in depth, below which and overlying the rock there was found a waterbearing stratum of sand, gravel and boulders, varying from 20 to 30 feet in thickness. The rock level was found at depths from 114 to 120 feet below street level.

The first six caissons for footings along one side of the lot were put down in the open, down through the clay. Up to this point, the volume of water encountered was so small that it could be hoisted out in buckets. On approaching the strata of water-bearing gravel and boulders (overlying the rock, the water came in so fast that any further attempt to put down these caissons in the open would have been difficult and dangerous, so that the work

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from this point, and on all remaining caissons, was continued under pneumatic pressure, as shown in sketch.

The caissons were excavated in groups of 6 to 10, placed so that the spoil could be hoisted out of them according to the most economical arrangement. Fig. 2 shows clearly the method of sinking these caissons with the aid of compressed air. It was found best to stop the open excavation at a point about 10 feet above the bottom of the clay. The first operation was to place the shield just below the original lagging at the bottom of the open excavation. The pit at this point was excavated 3 inches larger than the outside diameter of the shield, after which the latter was set up, bolted together, and four 10-ton screw jacks set in position around the lagging as shown. After the first ring of 2-inch lagging, directly above the shield, was in place, it was back-filled with a little clay for a seal, then some grout was poured in to help seal the air from going up along the back of the lagging.

At a point about 10 feet above the (original) lagging, a section of the latter was taken out and the material excavated outside of same for about 2 feet all around and for a height of about 6 feet. A collapsible steel air lock, of the Moran type, 4½ feet in diameter and 5½ feet high, was then concreted into the space as shown in Fig. 2. When concreting around the lock, a half-dozen 1-inch eye-bolts were put in the top of the concrete and hook bolts in the bottom. The hook bolts supported the lower lagging which was hung to them by ½-inch round iron (sketch no. 2). From the eye-bolts, ⅝-inch wire rope was run up to the top of the hole and fastened around cross-timbers spanning the shaft.

The shield used in carrying the excavation below the lot was 4 feet high and slightly larger in diameter than the bottom of the footing. It is built of steel plates equal in width to its height and in four equal sections. The latter are arranged to be joined from the inside after the sections have been taken through the air lock and set up in the caissons. At each joint, a butt strap rivetted the full width of the end of one section of the shield laps over the abutting end of another section. This strap is partially punched through with a row of holes threaded to receive the ends of screws through corresponding holes in the abutting section. The two sections could thus be assembled by placing the screws at each joint,

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and dismantled by removing these screws. An angle is rivetted horizontally to the inside of the shield near the bottom as a stiffener, and also as a brace against which the jacks used in pushing the shield down may be set. Joints between the four sections of this angle brace are made by means of double straps, bolted in place so they can be removed and the angles recovered later. (Fig. 1.)

Below the air lock, the excavation was lined with 2-inch tongued and grooved wooden lagging in 3-feet lengths. This lagging was assembled in sections by bolting both ends of each piece to a horizontal angle so that four of the sections comprised a circle

FIG. 1.

of the same diameter as the caisson on which the work was in progress. Each of these sections was made up on the surface and lowered through the air lock to the point where the excavation was in progress. The sets of four were assembled together in place by bolting the angles together with straps as in the case of the shield sections.

When the shield finally reached rock, the bolts in the angle near

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the cutting edge were removed so that this angle could be recovered. The concrete was then deposited in the bottom and carried up to the lock as rapidly as possible. The concrete was shot down into buckets on the top of the lock through an 8-inch sheet steel chute, from which point, the buckets were then lowered through the lock. As each of the circular angle braces on the wooden lagging was reached, the bolts in the angle were removed and the latter recovered. The lagging is thus left in place and is at all times safely braced, either by angles or by the concrete just deposited. After the concrete had been brought up to the bottom of the lock, the latter was collapsed by removing a key in one of the joints, between the two longitudinal sections of which it is composed, so that the same size lock could be used over and over again. (Fig. 2.)

The concrete was mixed in the proportion of one part Marquette Portland cement, three parts sand or stone screenings and five parts broken stone (that will pass a 1½-inch ring). The broken stone screenings were used in lieu of sand for the concrete in the footings while the sand was employed as the fine aggregate on all exposed concrete.

The material overlying the rock was of such a nature that it was found difficult to prevent the escape of large quantities of air. Through the loose gravel, the air passed quite readily. The sand was unlike the quicksand encountered in the lower part of Manhattan Island, N. Y. City, in that it would not hold back the air. As a result, the air was seen escaping from the top of the finished piers, and was later traced to a point about a half mile away where some other piers were being put down for a building, across the south branch of the Chicago River. On sinking these latter caissons in the open, a comparatively free flow of air was encountered when the stratum above the rock was reached. When the thick bed of clay had been cut through, the air traveled along under it through the water bearing stratus until it reached some point where an opening had been made through this clay, following up along the lagging left in place around piers previously completed, to the surface.

The work is of special interest for its novelty and originality in application to the construction of deep piers for city buildings. It is probably the first time that the method of "tunneling horizon-

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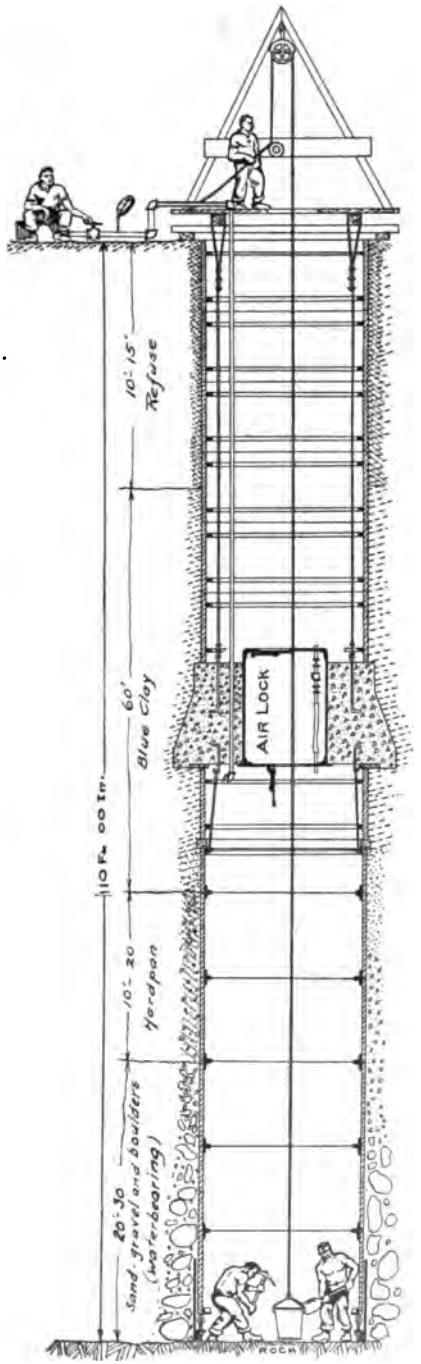
FIG. 2.



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tally" with the aid of a shield and compressed air was reversed and applied to "tunneling vertically." Generally, a pneumatic caisson is sunk down to rock by adding gradually to the top and loading it with pig iron to overcome the frictional resistance along the sides of the caisson. In this case, the pier was built from the "bottom up" in stages.

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CRYSTALLOGRAPHIC NOTES.

By H. P. WHITLOCK.

Additional Note on Datolite from the Erie Cut, Bergen Hill, N. J.

During the spring of 1909 the mineral collection of the New York State Museum acquired by exchange from Mr. James G. Manchester a handsome suite of specimens of crystallized datolite from the recent excavations through the trap formation at Bergen Hill for the Erie Railroad cut. On carefully studying this material, it was found that all four of the types described by E. S. Dana* from the original Bergen Hill locality were represented by the Erie Cut crystals and that 27 of the 44 forms recorded by him were present on these latter. In the course of this study two forms apparently new to the species were encountered.

In view of these facts it has seemed justifiable to submit the following note on the crystallography of the datolite from the Erie Cut and to correlate the crystals from this locality with the original types as described by Dana.

The forms of datolite from Bergen Hill recorded by E. S. Dana are given in the following correlation table.

The zonal relations of these forms are shown on the gnomonic projection, Plate I, the forms present on the Erie Cut crystals being distinguished by double circles.

The forms noted in the sixth column of the above table were determined by the measurement of twenty selected crystals chosen from a series of about eighty. The entire series which was furnished by twelve specimens thickly encrusted with datolite crystals was carefully studied with a hand lens, thus ensuring the selected crystals to be representative of the occurrence.

The crystals of the simplest habit are essentially identical with the first type of Dana,† and combine the forms: $a(100)$, $c(001)$,

* Dana, E. S., "On the Datolite from Bergen Hill, New Jersey," *Am. Jour. Sci.*, 1872, 3, IV., 16.

† *Loc. cit.*, Fig. 1. Also J. D. Dana, "System of Mineralogy," 6th ed., p. 503, Fig. 1.

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FORMS RECORDED BY E. S. DANA ON DATOLITE FROM BERGEN HILL.

Letter.	Dana Symbol, 1872.	Dana Symbol.	Miller Symbol, Dana Orientation.	Miller Symbol, Goldschmidt Orientation.	Forms noted from Erie Cut.	Letter.	Dana Symbol, 1872.	Dana Symbol.	Miller Symbol, Dana Orientation.	Miller Symbol, Goldschmidt Orientation.	Forms noted from Erie Cut.
a	*ii*	*ii*	100	001	*a*	κ	$\frac{4}{5}$	$\frac{1}{5}$	$\bar{1}15$	$\bar{5}22$	κ
b	*i*$\dot{1}$	*i*$\dot{1}$	010	010	*b*	ω	$\frac{2}{3}$	$\frac{1}{3}$	$\bar{1}16$	$\bar{3}11$	
c	0	0	001	100	*c*	θ	—42	—1—2	$\bar{2}12$	$\bar{1}12$	
η	*i*4	*i*4	410	014		Ψ	—44	—1—4	$\bar{4}14$	$\bar{2}14$	
Δ	*i*2	*i*2	210	012		ι	42	1—2	$\bar{2}12$	$\bar{1}12$	
m	*I*	*I*	110	011	*m*	*N*	$-6\frac{1}{2}$	$-\frac{1}{2}-\frac{1}{2}$	$\bar{3}22$	$\bar{1}23$	*N*
r	$i\frac{1}{3}$	$i-\frac{1}{3}$	230	032	*r*	*q*	$-6\frac{1}{3}$	$-\frac{1}{2}-\frac{1}{3}$	$\bar{3}12$	$\bar{1}13$	*q*
o	*i*2	*i*—2	120	021	*o*	*Q*	—42	—1—2	$\bar{1}22$	$\bar{1}21$	*Q*
l	*i*3	*i*—3	130	031	*l*	β	—82	—2—2	$\bar{1}21$	$\bar{1}42$	β
u	—1*i*	$-\frac{1}{4}-i$	104	201	*u*	*i*	$\frac{1}{3}2$	$\frac{2}{3}-2$	$\bar{1}23$	$\bar{3}42$	
	$-\frac{3}{4}i$	$-\frac{3}{16}-i$	3·0·16	803		α	22	$\frac{1}{2}-2$	$\bar{1}24$	$\bar{2}21$	α
x	—2*i*	$-\frac{1}{2}-i$	102	101	*x*	*D*	—43	—1—3	$\bar{1}33$	$\bar{3}62$	
φ	—4*i*	—1—*i*	101	102		*E*	$\frac{4}{3}3$	$\frac{1}{3}-3$	$\bar{1}38$	$\bar{4}31$	
s	—6*i*	$-\frac{3}{2}-i$	302	103	*s*	*F*	$\frac{5}{3}3$	$\frac{5}{6}-3$	$\bar{5}\cdot15\cdot24$	$\bar{1}2\cdot15\cdot5$	
ψ	—8*i*	—2—*i*	201	104	ψ	π	$12\frac{1}{2}$	$3-\frac{1}{2}$	$\bar{2}31$	$\bar{1}64$	π
ξ	2*i*	$\frac{1}{2}-i$	102	101	ξ	*K*	$\frac{5}{3}5$	$\frac{1}{6}-5$	$\bar{1}58$	$\bar{4}51$	
Ω	$\frac{1}{3}i$	$\frac{1}{6}-i$	018	410		*G*	$\frac{9}{2}9$	$\frac{9}{16}-9$	$\bar{1}\cdot9\cdot16$	$\bar{8}91$	
σ	$i\frac{1}{2}$	$\frac{1}{4}-i$	014	210							
ζ	$\frac{4}{3}i$	$\frac{1}{3}-i$	013	320	ζ			DOUBTFUL FORMS.			
g	2*i*	$\frac{1}{2}-i$	012	110	*g*						
m_x	4*i*	1—*i*	011	120	m_x	$\bar{m}$	$-6\frac{1}{2}$	$-\frac{1}{2}-\frac{1}{2}$	$\bar{2}32$	$\bar{1}32$	
n	—4	—1	111	122	*n*	Θ	$\frac{5}{7}4$	$\frac{2}{7}-4$	$\bar{1}\cdot4\cdot14$	$\bar{7}41$	
ν	4	1	$\bar{1}11$	$\bar{1}22$	ν	τ	$\frac{8}{9}\frac{4}{3}$	$\frac{2}{9}-\frac{4}{3}$	$\bar{3}\cdot4\cdot18$	$\bar{9}43$	
ϵ	2	$\frac{1}{2}$	$\bar{1}12$	$\bar{1}11$	ϵ						
λ	$\frac{4}{3}$	$\frac{1}{3}$	$\bar{1}13$	$\bar{3}22$	λ						
μ	1	$\frac{1}{4}$	$\bar{1}14$	$\bar{2}11$	μ						

The first column gives the letter as adopted by Dana and Goldschmidt.

The second column gives the Dana symbol as used in the paper cited.

The third column gives the transformed Dana symbol in which $c = 4c$ of the symbol of the second column.

The fourth column gives the Miller symbol corresponding to Dana's orientation (third column).

The fifth column gives the Miller symbol corresponding to Goldschmidt's orientation. This is related to Dana's orientation as follows: a (Goldschmidt) = $\frac{1}{2}c$ (Dana), c (Goldschmidt) = a (Dana).

The sixth column gives the letters of those forms found by the writer on crystals from the Erie Cut.

$m(110)$, $m_x(011)$, $n(111)$, $\mu(\bar{1}14)$ and $\epsilon(\bar{1}12)$. Crystals of this type were described in a short note by Messrs. Ford and Pogue* in

* Ford, W. E., and Pogue, J. L., "Crystals of Datolite from Bergen Hill, N. J.," *Am. Jour. Sci.*, 1909, 4, XXVIII., 187.

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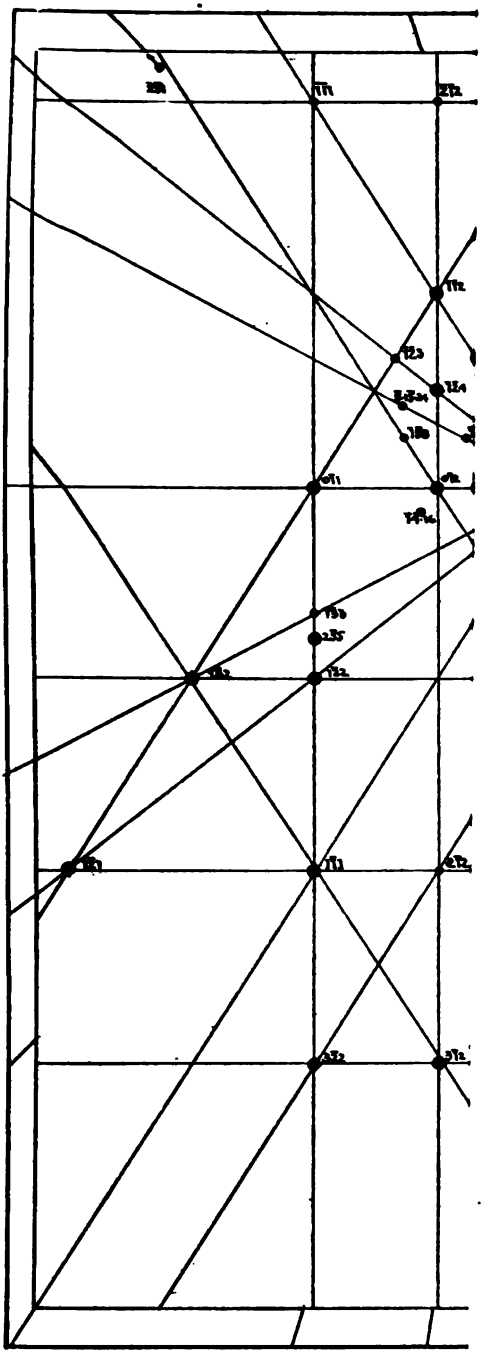

Gnomonic projection of the crystal forms of dat
from the Erie

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which these writers gave the pyramid series as $W(114)$, $\Lambda(112)$ and $\nu(111)$. With the exception of $\nu(\bar{1}11)$ these latter forms have not hitherto been found on datolite from Bergen Hill, whereas the corresponding forms in reversed position, *i. e.*, $(\bar{1}14)$, $(\bar{1}12)$ and (111), are common to that occurrence. It should be borne in mind in this connection that the difference in orientation for the unit series of pyramids of datolite, between the positive forms and the corresponding negative forms in reversed position is extremely slight; for instance, the theoretical values of the angles $m:n$ and $m:\nu$ are:

$$m:n = 110:111 = 22° 56'$$
$$m:\nu = 110:\bar{1}11 = 22\ 57$$

Crystals XIX. and XX. represent this type, a combination of which is shown in Plate II., Fig. 1.

The second type of Dana which is marked by the prominence of the basal pinacoid occurs on one specimen associated with calcite, and is represented by crystal XVIII. This combination is shown in Plate II., Fig. 2. The forms $a(100)$, $c(001)$, $m(110)$, $g(012)$, $m_g(011)$, $n(111)$, $\mu(\bar{1}14)$ and $\epsilon(\bar{1}12)$ were noted. The forms x (102), $\xi(\bar{1}02)$, $\iota(\bar{2}12)$, $\lambda(\bar{1}13)$, $\kappa(\bar{1}15)$, $\omega(\bar{1}16)$, $t(013)$ and $\beta(121)$ mentioned by Dana as occurring on crystals of this habit were not noted on the materials from the Erie Cut.

The third type of Dana occurs on three specimens of the series from Erie Cut and is represented by crystals XVI. and XVII. The type is here characterized by the presence of the rounded planes of the positive hemi orthodomes $s(302)$ and $\psi(201)$ between (100) and (102). Two habits of this type shown in Plate II., Figs. 3 and 4 were observed, the latter of which conforms closely to the combination shown in Fig. 6 of Dana's paper. The forms $a(100)$, $c(001)$, $m(110)$, $x(102)$, $s(302)$, $\psi(201)$, $g(012)$, $m_g(011)$, $n(111)$, $\mu(\bar{1}14)$, $\lambda(\bar{1}13)$ and $\epsilon(\bar{1}12)$ were noted.

The fourth type of Dana is represented by the most complex and interesting of the datolite crystals from the Erie Cut. This type was studied in crystals I.–XV. and is shown in some of its variations in Plate II., Figs. 5, 6 and 7. Apparently the determining character of this type is the presence of forms situated in zones other than [001.010], [001.100] and [001.110], see plate I. Be-

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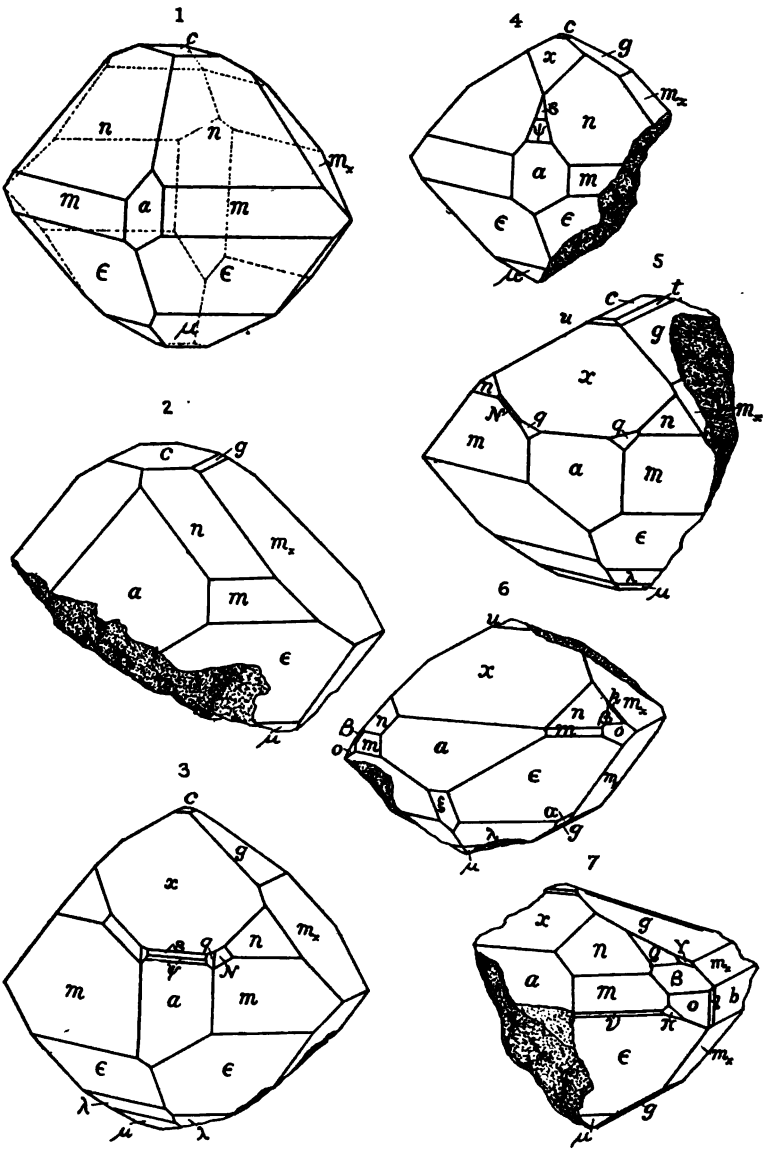
PLATE II.



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sides the forms $a(100)$, $b(010)$, $c(001)$, $m(110)$, $r(230)$, $o(120)$, $l(130)$, $u(104)$, $x(\bar{1}02)$, $\xi(102)$, $t(013)$, $g(012)$, $m_x(011)$, $n(111)$, $\kappa(\bar{1}15)$, $\mu(\bar{1}14)$, $\lambda(\bar{1}13)$, $\epsilon(\bar{1}12)$, $\nu(\bar{1}11)$, $q(312)$, $N(322)$, $Q(122)$, $\beta(121)$, $\pi(\bar{2}31)$ and $\alpha(\bar{1}24)$ observed by Dana on the crystals from Bergen Hill, two pyramids apparently new to the species were noted, viz: $k(132)$ and $Y(255)$. The crystals in general are more brilliant and gave better reflections than those of the types previously mentioned.

Of the new forms, $k(132)$ was noted on ten crystals of the suite measured as an exceedingly narrow series of planes. In several instances only one plane of the form was noted on a single crystal. The form which lies in the zone [011.121.110] was determined by its angular distance from (011) in that zone as follows:

		Measured.	Calculated.	Readings.
$m_x:k$	011 : 132	26° 17′	26° 15½′	10

In the case of crystals VII., VIII. and XIII. the position of the form (132) was further checked by locating it in the zone [312.111]. The planes are in most instances reduced to mere lines and the reflections though faint were fairly distinct.

The pyramid $Y(255)$ was observed on only one of the crystals measured, crystal X. The single plane of this form noted is small but well defined and gave a fair reflection of the goniometer signal. The form which lies in the zone [100.011] was determined by verifying this zonal relation and by the following measurements:

		Measured.	Calculated.
$m:Y$	011 : 255	26° 21′	26° 21½′
$b:Y$	010 : 255	45 27	45 18

The following table gives the distribution of forms on the twenty crystals measured.

PLATE II.

Datolite from the Erie Cut, Bergen Hill, N. J.

1. Type I. Crystal XX. Forms: $a(100)$, $c(001)$, $m(110)$, $m_x(011)$, $n(111)$, $\mu(\bar{1}14)$ and $\epsilon(\bar{1}12)$.

2. Type II. Crystal XVIII. Forms: $a(100)$, $c(001)$, $m(110)$, $g(012)$, $m_x(011)$, $n(111)$, $\mu(\bar{1}14)$ and $\epsilon(\bar{1}12)$.

3. Type III. Crystal XVI. Forms: $a(100)$, $c(001)$, $m(110)$, $x(102)$, $s(302)$, $\psi(201)$, $g(012)$, $m(011)$, $n(111)$, $\mu(\bar{1}14)$, $\lambda(\bar{1}13)$, $\epsilon(\bar{1}12)$, $q(312)$ and $N(322)$.

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SUMMARY OF DISTRIBUTION OF FORMS.

Letter.	Symbol.	Crystal. I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	
a	100	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	
b	010										*b*	*b*										
c	001	*c*	*c*		*c*	*c*		*c*	*c*		*c*		*c*	*c*	*c*		*c*	*c*	*c*	*c*	*c*	
m	110	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	
r	230													*r*	*r*							
o	120	*o*		*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*	*o*						
l	130										*l*	*l*										
u	104	*u*	*u*			*u*					*u*	*u*	*u*	*u*	*u*	*u*						
x	102	*x*	*x*		*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*				
s	302																*s*	*s*				
ψ	201																*ψ*	*ψ*				
ξ	102	*ξ*			*ξ*	*ξ*				*ξ*	*ξ*			*ξ*		*ξ*						
t	013	*t*	*t*		*t*			*t*	*t*	*t*			*t*	*t*	*t*	*t*						
g	012	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*	*g*			
m_x	011	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	m_x	
n	111	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	
κ	115	*κ*	*κ*			*κ*		*κ*	*κ*													
μ	114	*μ*	*μ*	*μ*	*μ*	*μ*	*μ*	*μ*	*μ*	*μ*	*μ*		*μ*	*μ*		*u*	*μ*	*μ*	*μ*	*μ*	*μ*	
λ	113	*λ*	*λ*	*λ*	*λ*	*λ*		*λ*	*λ*	*λ*			*λ*	*λ*	*λ*	*λ*	*λ*					
ε	112	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	*ε*	
ν	111										*ν*											
q	312		*q*				*q*	*q*	*q*				*q*	*q*	*q*		*q*					
N	322	*N*							*N*								*N*					
Q	122				*Q*					*Q*	*Q*	*Q*	*Q*									
β	121	*β*		*β*	*β*	*β*	*β*	*β*	*β*	*β*	*β*			*β*	*β*	*β*						
π	231										*π*				*π*							
α	124	*α*		*α*									*α*			*α*						
k	132			*k*	*k*	*k*	*k*	*k*	*k*	*k*				*k*	*k*	*k*						new
Y	255										*Y*											new

4. Type III. Crystal XVII. Forms: *a*(100), *c*(001), *m*(110), *x*(102), *s*(302), *ψ*(201), *g*(012), m_x(011), *n*(111), *μ*(1̄14) and *ε*(1̄12).

5. Type IV. Crystal II. Forms: *a*(100), *c*(001), *m*(110), *u*(104), *x*(102), *t*(013), *g*(012), m_x(011), *n*(111), *κ*(1̄15), *μ*(1̄14), *λ*(1̄13), *ε*(1̄12), *q*(312) and *N*(322).

6. Type IV. Crystal XV. Forms: *a*(100), *m*(110), *o*(120), *u*(104), *x*(102), *ξ*(1̄02), *g*(012), m_x(011), *n*(111), *μ*(1̄14), *λ*(1̄13), *ε*(112), *β*(121), *α*(124) and *k*(123).

7. Type IV. Crystal X. Forms: *a*(100), *b*(010), *c*(001), *m*(110), *o*(120), *l*(130), *u*(104), *x*(102), *g*(012), m_x(011), *n*(111), *μ*(1̄14), *ε*(1̄12), *ν*(1̄11), *Q*(122), *β*(121), *π*(231) and *Y*(255).

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Apophyllite from the Erie Cut, Bergen Hill, N. J.

A new pyramid was noted on a single large crystal of apophyllite from the Erie Cut, Bergen Hill, which was loaned for study through the courtesy of Mr. James C. Manchester, of New York. The crystal which measures about 4 centimeters in vertical length is partly embedded in a matrix thickly encrusted with small apophyllite crystals. The new pyramid is present as a series of eight narrow, but well-developed planes, truncating the edges between $a(100)$ and $p(111)$. The angles measured for this form correspond to the indices (711) and the letter h has been assigned to it. The crystal which is shown in Fig. 1 exhibits the following forms: $c(001)$, $a(100)$, $y(310)$, $p(111)$ and $h(711)$. The new form was determined from the following measured angles:

Summary of Measured and Calculated Angles.

Letter.	Angle.	No. of Readings.	Measured.	Calculated.
$h : h^{vii}$	$711 : 7\bar{1}1$	2	16° 3′	16° 9′
$h : h'$	$711 : 171$	1	73 30	73 52½
$a : h$	$100 : 711$	4	9 50	10 22

Calcite Crystals of Pyramidal Habit from Kelley's Island, O.

Shortly after the publication of a note on the pyramidal calcite crystals from Kelley's Island by Messrs. Ford and Pogue,* the New York State Museum acquired through Mr. C. H. Jones, of New York, a representative series of these interesting crystals. It at once became apparent that several of these specimens represented a crystallographic combination much more complex than that described by Ford and Pogue and a subsequent study of this type resulted in the identification of two forms new to the species. This, coupled with the fact that calcite crystals of pyramidal habit have recently furnished the writer with material for study from a crystallogenetic point of view, has led to the following additional note on the Kelley's Island occurrence.

The specimens available for study were obtained from two quarries distant about a mile from each other. The calcite from

* Ford, W. E., and Pogue, J. L., "Calcite Crystals from Kelley's Island, Lake Erie," *Am. Jour. Sci.*, 1909, 28, 186.

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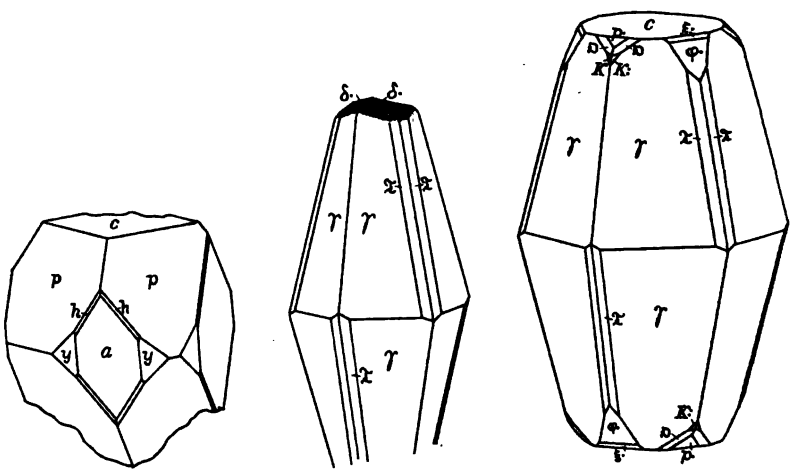
both quarries occurs in Upper Siluric limestone of Rondout or Cobleskill formation, considerably decomposed and yielding on solution quartz in microscopic irregular grains. The matrix of the crystals of the more complex habit is strongly permeated with petroleum and shows abundant chert nodules in close proximity to the vugs containing the calcite crystals. The evidence of calcite deposition from a solution heavily charged with silica is striking. particularly in the case of the more complex type of calcite crystals.

The calcite crystals of the less complex habit which were described by Ford and Pogue are transparent, light honey-yellow in color and average 4 centimeters in vertical length. In addition to the pyramid $\gamma(8.8.\bar{16}.3)$ and the negative rhombohedron $\delta.(01\bar{1}2)$ observed by the above authors, a new negative scaleno-

FIG. 1. FIG. 2. FIG. 3.



Apophylite Erie Cut. Calcite, Kelley's Island.

hedron bevelling the polar edges of the pyramid was noted. This scalenohedron to which the letter $\mathfrak{X}$ has been assigned was also noted on the more complex combination and gave values from four sets of measured angles corresponding to the indices $(6.13.\bar{19}.4)$. A typical crystal of this habit is shown in Fig. 2.

The crystals of the more complex habit shown in Fig. 3 are

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colorless, transparent and average one centimeter in vertical length. Crystallographically they differ from those previously described principally in the presence of the basal pinacoid $o(0001)$ which takes the place of $\delta.(01\bar{1}2)$ in termination. The planes of this form are beautifully smooth and brilliant, giving fine reflections of the goniometer signal and constituting excellent points of reference for all faces.

In the rhombohedral zone, the negative rhombohedron $\phi.(02\bar{2}1)$ is universally present as a series of bright, well-developed planes. The positive rhombohedron $p.(10\bar{1}1)$ is frequent though developed to a somewhat less extent than ϕ. On two of the crystals measured narrow planes of the negative rhombohedrous $\xi.(04\bar{4}3)$ were noted.

Small but well-developed planes of the positive scalenohedron K: $(21\bar{3}1)$ are very commonly present in crystals of this habit. The new negative rhombohedron $\mathfrak{T}(6.13.\bar{19}.4)$ of the previously described combination is also very commonly present. Less common, but still quite frequent in occurrence, is the new positive scalenohedron $\mathfrak{D}(21.5.\bar{26}.18.)$ which modifies the edges between $(10\bar{1}1)$ and $(8.8.\bar{16}.3)$, lying very nearly in zone with these two forms. It was at first assumed that this form lay in the zone above mentioned, but careful adjustment showed in every instance a slight displacement of the image of the signal from that of the zone of the two adjacent faces. The form was identified from four series of measured angles, all of which agree fairly well with the calculated values, so that in spite of the high indexes the form seems to be well established.

The new negative scalenohedron not only lies in the zone $[\bar{8}081 \ . \ 8.8.\bar{16}.3 \ . \ 04\bar{4}1]$ as verified by observation but also lies at the intersection of the following zones: $[3\bar{3}02 \ . \ 0110]$ and $[0.13.\bar{13}.4 \ . \ 10\bar{1}0]$.

All of the planes of this habit show sharply defined natural etch pits.

The following angles were measured:

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SUMMARY OF MEASURED AND CALCULATED ANGLES.

Letter.	Angle.	No. of Readings.	Measured.	Calculated.
			° ′	° ′
$o:\phi$.	0001 : $10\bar{1}1$	3	44 34	44 36½
$o:\phi$.	0001 : $02\bar{2}1$	8	63 9½	63 7
$o:\xi$.	0001 : $04\bar{4}3$	3	52 30½	52 45
$o:\gamma$	0001 : 8.8.$\bar{16}$.3	5	77 32	77 37
$\gamma:\gamma$	8.8.$\bar{16}$.3 : $\bar{8}$.16.$\bar{8}$.3	5	58 31	58 28
$\phi.:K$:	$02\bar{2}1$: $21\bar{3}1$	4	37 42	37 41
$K::K$:	$21\bar{3}1$: $3\bar{1}2\bar{1}$	2	35 23½	35 36
$\mathfrak{D}:\mathfrak{D}$	21.5.$\bar{26}$.18 : $\bar{2}$1.26.$\bar{5}$.18	4	73 43	73 27½
$\mathfrak{D}:\mathfrak{D}$	21.5.$\bar{26}$.18 : 26.$\bar{5}$.$\bar{2}$1.18	6	16 43½	16 45
$\mathfrak{D}:\mathfrak{D}$	21.5.$\bar{26}$.18 : $\bar{5}$.$\bar{2}$1.26.18	4	96 35½	96 31½
$o:\mathfrak{D}$	0001 : 21.5.$\bar{26}$.18	12	52 12½	52 10
$\mathfrak{T}:\mathfrak{T}$	6.13.$\bar{19}$.4 : 19.$\bar{13}$.$\bar{6}$.4	9	81 0	81 10½
$\mathfrak{T}:\mathfrak{T}$	6.13.$\bar{19}$.4 : $\bar{6}$.19.$\bar{13}$.4	13	34 42	34 56½
$\mathfrak{T}:\mathfrak{T}$	6.13.$\bar{19}$.4 : 13.6.$\bar{19}$.$\bar{4}$	3	36 9	36 3½
$o:\mathfrak{T}$	0001 : 6.13.$\bar{19}$.4	6	76 3	76 26½

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A REPLACEMENT OF RHYOLITE PORPHYRY BY STEPHANITE AND CHALCOPYRITE AT LEADVILLE.

By CLARENCE N. FENNER.

During the past fall Mr. Hover, a fourth-year student of the School of Mines at Columbia, brought into the Geological Department a specimen of what was believed to be argentite ore coming from the Silver Cord Claim at Leadville, Colo.

Certain slight peculiarities in the appearance of the ore aroused some curiosity and induced the writer to carry on a further study of the specimen by metallographic and petrographic methods. An unexpected and interesting form of metasomatic replacement was brought out.

In the hand specimen the ore is seen to consist of a small amount of chalcopyrite, associated with a light-gray mineral resembling tetrahedrite and composing most of the mass. There is a slight sprinkling of silicate material throughout.

Preliminary to the optical examination blowpipe tests were made to determine the nature of the gray mineral. A portion which appeared to be free from chalcopyrite gave decisive tests for sulphur and antimony and yielded on coal a pink coat of silver oxide. By reduction with soda a silver button was obtained, which, upon solution in nitric acid and addition of ammonia, gave no indication of copper. The reactions show the mineral to be stephanite. In the subsequent examination of polished surfaces it was found that the stephanite contained no admixture of any metallic mineral except chalcopyrite and a few pyrite granules, and it must be concluded that argentite is absent.

A petrographic examination of a thin section of a portion of the ore in which silicates were most abundant showed the relations sketched in Fig. 1. Well-developed and surprisingly fresh-looking phenocrysts of feldspar and quartz are imbedded in a groundmass which consists largely of stephanite. A portion of the original silicate groundmass survives, but appears to have been of

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very fine grain and is now so altered that none of the constituents can be recognized. It appears very dense and of a dark brownish-green color. The feldspars range in length from 2 mm. down to 0.3 mm. and are of strongly idiomorphic development. The recognizable crystal faces are the ortho- and clinopinacoids, clinodome and a low hemiorthodome. The last is the prominent terminal face in many crystals and as a result the characteristic habit is nearly rectangular.

Though the substance of the feldspars is fresh there are many embayments and inclusions which appear to be due chiefly to

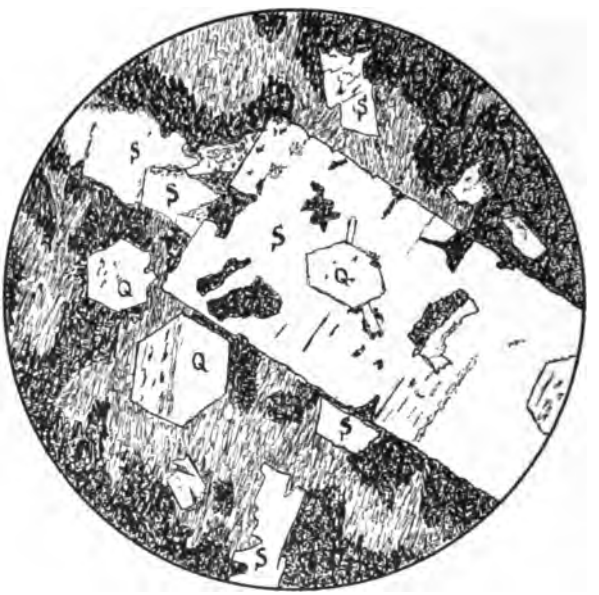

FIG. 1. Petrographic section. Sanidine and quartz phenocrysts. Very dark gray areas are altered groundmass, light gray is stephanite. Magnification 50 diam.

magmatic resorption rather than to later corrosion by ore-bearing solutions, as the irregularities are often occupied by silicate groundmass. Optical character biaxial and negative, optical angle very small. Extinction angle is also small, not over 2–3° as a maximum. Polysynthetic twinning is entirely absent. Carlsbad twintion angles. A few crystals exhibit an interpenetration twinning ning absent or not recognizable on account of low value of extincwhose character was not determined. Zonal growth frequently

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observable and in some cases very prominent. The characteristics are those of the soda-bearing orthoclase of acid porphyries—sanidine.

The quartz, which is found in much smaller amount than the sanidine, is typically in idiomorphic phenocrysts of hexagonal outline, but often exhibits inclusions of groundmass, deep embayments, and much resorption of the form produced by magmatic corrosion. In the quartz also there is some form of contact-twinning, which gives different interference colors in adjacent parts of a single crystal. A common size of grain is 0.2–0.6 mm. Neither quartz nor sanidine exhibits crushing or evidence of strain.

FIG. 2. Resorbed sanidine phenocrysts in stephanite. Minute lathlike feldspars have in many places a flow-structure. Magnification 40 diam.

Polished sections examined by metallographic methods add considerably to the information obtained. Figs. 2–5 illustrate the relations observed.

In Fig. 2 the corroded phenocrysts of sanidine are seen to lie imbedded in a groundmass in which the original finely granular silicates have been almost completely replaced by stephanite. This is the general relation in most parts of the specimen. The

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small amount of original groundmass which survives consists largely of minute rods, which in some cases can be identified as feldspar microlites. They are frequently disposed in an undoubted flow-structure. The general association is that of a rhyolite-porphyry.

In general the areas of stephanite and of chalcopyrite in the specimen are quite distinct and there is little mingling of the two except where the areas adjoin. Fig. 3 shows the typical relations

FIG. 3. Q = quartz, showing considerable magmatic resorption and inclusions of chalcopyrite, P = corroded pyrite, A = areas which may represent phenocrysts of some unknown mineral, or more probably pyrite almost wholly replaced by chalcopyrite. The form is outlined by silicate groundmass (shown dark). Remainder of material is chalcopyrite with minute silicate inclusions. Magnification 40 diam.

in an area of chalcopyrite, about one inch in diameter, which crosses the specimen. Numerous phenocrysts are scattered throughout this area. They show considerable magmatic resorption and numerous inclusions of chalcopyrite, which appears to replace originally included groundmass. In the areas marked A, the outlines are suggestive of phenocrysts, but may instead mark the former extent of pyrite crystals, which have been corroded and

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largely replaced by chalcopyrite, which now forms the general groundmass. The chalcopyrite contains minute silicate inclusions.

Wherever the areas of stephanite and chalcopyrite adjoin the stephanite projects into the chalcopyrite in the manner shown in Figs. 4 and 5. Careful study of the form and mode of grouping of these stephanite areas has convinced the writer that they outline

FIG. 4. Clear = stephanite, stippled = chalcopyrite, large phenocrysts = sanidine. Magnification 40–45 diam.

feldspar laths of the original groundmass. All the characteristics of outline and habit which are distinctive of such feldspar microlites are reproduced in many cases with the utmost fidelity. A disposition in flow-structure is also apparent in places. The relations may perhaps be accounted for in the following manner. The solutions from which the chalcopyrite was deposited would seem to have first impregnated the porphyry and by a process of metasomatic replacement the chalcopyrite was substituted for the silicate minerals of the groundmass. Among these minerals the feldspars appear to have been most resistant and to have been the last to yield, so that along the borders of the replacement areas these microlites were left undisturbed as inclusions and projections

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in the chalcopyrite. At a later stage silver-bearing solutions by a similar process deposited stephanite. In this case replacement proceeded farther and many of the feldspar microlites which survived the previous stage were replaced by the silver mineral.

In the literature of the Leadville deposits all observers appear to accept the view that the sulphide minerals which form the ore-

FIG. 5. Dark-gray = unreplaced silicate material, largely feldspathic, clear = stephanite, stippled = chalcopyrite. Magnification 112 diam.

bodies replace sedimentary beds—almost universally limestone. The evidence that rich silver minerals have also replaced the igneous rocks of the district presents a new point of view for the consideration of the processes of replacement and may have some practical importance.

Thanks are due to Mr. Hover for the specimen studied and to the departments of geology and metallurgy for the use of apparatus. The writer is also grateful to Professor Berkey and Professor Campbell for suggestions made and interest shown.

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A NEW METALLOGRAPHIC MICROSCOPE.

By WM. CAMPBELL.

In the microscopic examination of opaque material, iron, steel, alloys, furnace products, ores, etc., the mounting of the specimen, so that the optical axis of the microscope is perpendicular to the surface of the specimen, consumes time and often takes much patience with the ordinary type of microscope.

The first great improvement was the Le Chatelier type of microscope (already mentioned in these pages*), in which the specimen was placed face downwards on the stage of the microscope and the objective pointed upwards from below. Thus we could use specimens of widely differing size and shape with perfect ease and no time was wasted in mounting or levelling.

After using the Le Chatelier microscope for some time the need of certain changes was felt, such as a heavier stage which could be moved by the usual rack and pinion, a simple method of changing the objective without moving the specimen from the stage, an eyepiece tube which could be moved to suit different heights and so forth. On enquiry of the firm of E. Leitz it was found that they had under way such a microscope following certain lines suggested by Dr. W. Guertler, and that the above changes would be embodied if found practical.

The most important feature of such a microscope is the system of illumination, which has been perfected† so that it is now adjustable. The compactness of the equipment can be seen in Figs. 1 and 2. The stand S consists of an upright which carries the microscope tube and the illuminating apparatus. The stage T may be raised or lowered by the rack and pinion and the fine adjustment M. The camera is attached by firm uprights to the frame B_1 which is fixed in position on the base of the microscope and lamp, B_2, by the wing-screw r. When using the camera, adjustment of

* School of Mines Quarterly, Vol. 25, p. 403; Vol. 27, p. 418.

† Dr. W. V. Ignatowsky, "Illuminating System for Metallographic Microscope," *Zeits. f. wiss. Mikroskopie*, XXV., No. 4, 1909.

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lamp and stage is made by F_1 and F_2. The source of light is a 4-ampere 90° arc attached to column S_1 and can be raised or lowered by means of the rack and pinion. It requires a small external resistance shown in Fig. 2.

When not using the camera the eyepiece O comes into play by

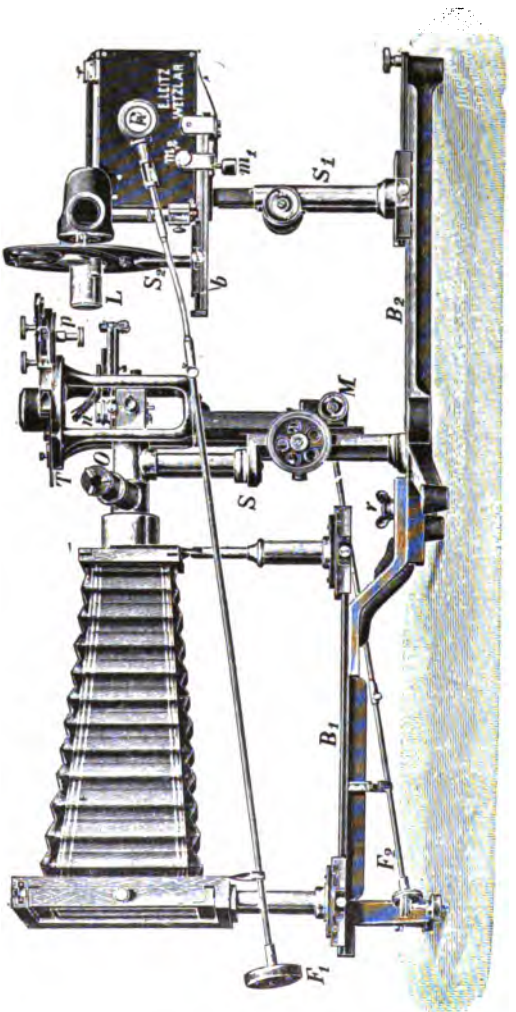

Fig. 1.

rack and pinion, for it is fitted to a sliding tube at the end of which is a prism to deflect the image at 90° along this eyepiece tube. In Fig. 3 the objective O is seen screwed into the slide R_1 permitting of easy removal. By means of the head R and handle n

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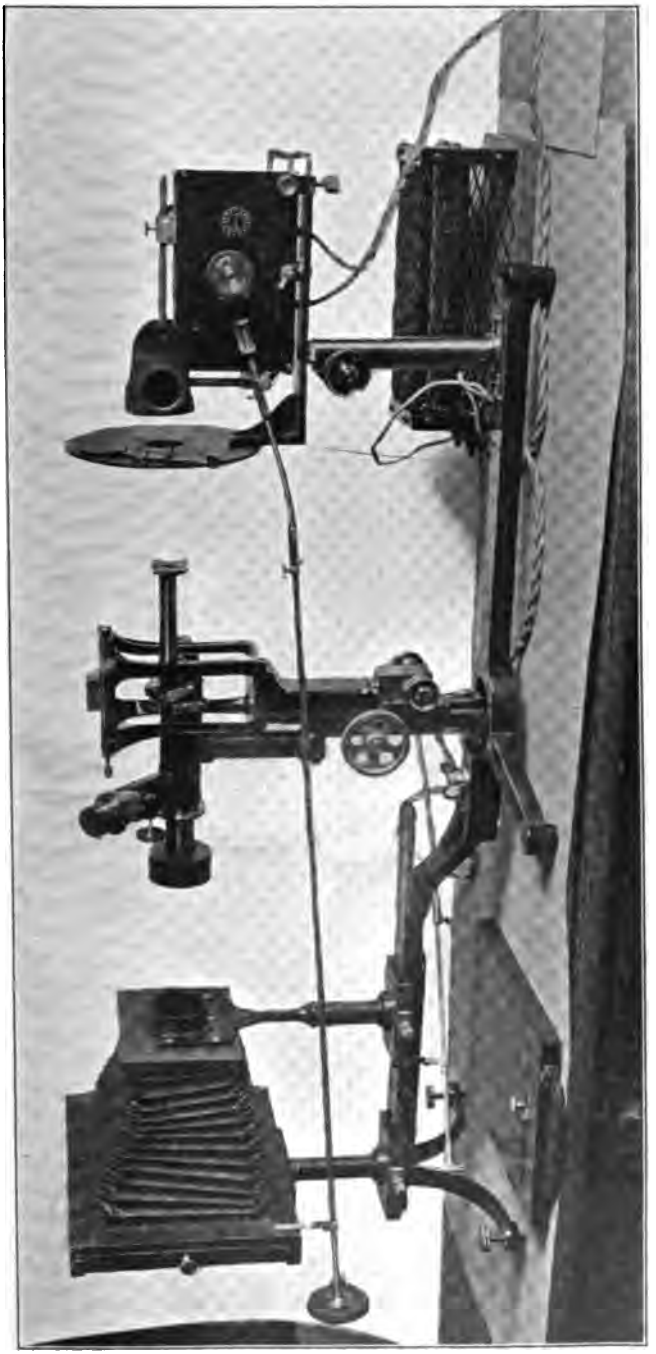

FIG. 2.

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the illuminating prisms can be adjusted and the beam of light varied by moving the lens attached to the milled head *S*. The end of the illuminating tube *B* is fitted with clips *h* to hold color screens. The beam of light can be widened and cut down by the iris diaphragm *I*, behind which is a shutter.

The working of the optical system is shown in Fig. 4. *B* represents the arc, *J* the iris diaphragm. The lens L^1 within the tube can be adjusted (by moving *s* in Fig. 3) so that an image of the iris is formed at *E* midway above the upper face of the prism *P*

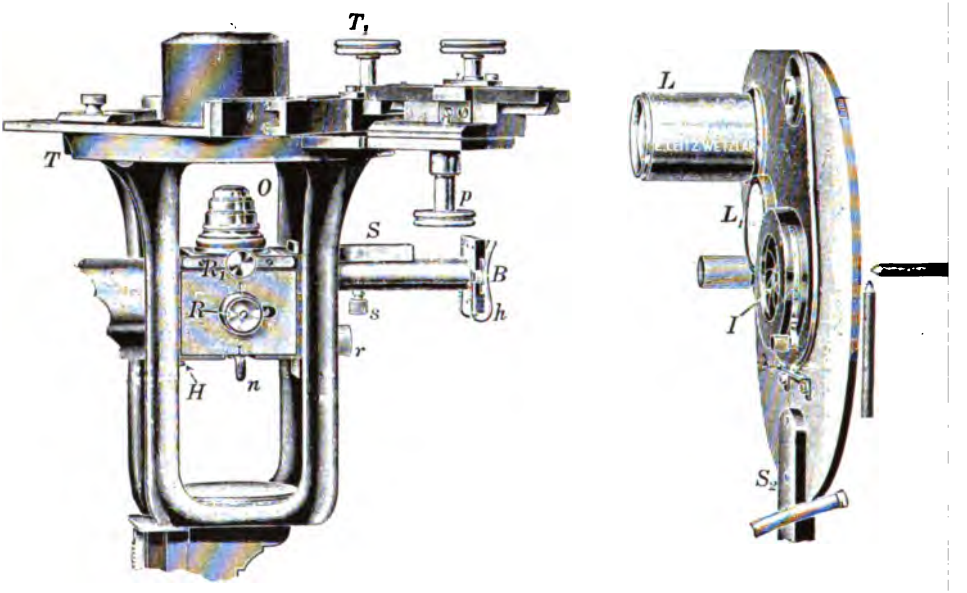

FIG. 3.

which by means of *R* (Fig. 3) may be moved backwards or forwards along the line *AB* and also tilted in the vertical plane. The rays of light pass through the objective *O* and illuminate the surface of the specimen *M* which lies face downwards on the stage. From the specimen part of the rays are reflected through the objective *O* onto the prism P^1 and thence to the eyepiece to form the image. This second prism is also capable of adjustment in the vertical plane parallel to the axis of the microscope, by moving the handle *n* (Fig. 3). Thus by adjusting the lens L^1 and the two prisms *P* and P^1 we are able to eliminate stray and reflected light which causes the blurred pictures and images in ordinary microscopes using reflected light.

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For low magnifications another method of illumination is used, similar to that advocated so long ago by Stead, and this is seen in Fig. 1. A thin glass plate is fixed above the low-power objective at *n* and the arc light raised until the light passing through the lens *L* strikes the glass plate *n* and is deflected onto the surface of the specimen and illuminates it.

In Figs. 1 and 3 the Guertler Mechanical stage* is shown, which has a compound cross motion given by the two milled heads T_1

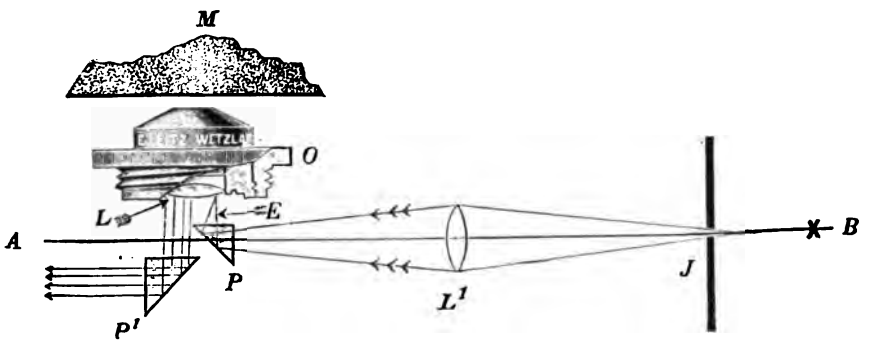

FIG. 4.

and which may be read by two vernier scales to 0.1 mm. By means of a couple of sliding arms any given spot on the specimen surface can be readily found. The whole is attached to the regular stage *T* by the clamp *p* (Fig. 3).

For ordinary work, however, the stage, as shown in Fig. 2, is used. When soft material is examined the brass stage-rings on which the specimen rests may be replaced by others of glass, as with the latter there is less tendency towards scratches caused by grit when the specimen is moved.

Thus this new microscope, called the micro-metallograph, has an adjustable system of illumination; a heavy stage-frame which can be fitted with a mechanical stage; a draw plate for changing the objective without moving the specimen from the stage; an adjustable eyepiece tube; and in addition is very compact and strong, whilst the arc lamp is part of the stand and requires but a small sized resistance. Compared with the older types of microscope and the larger arc-light illumination, this instrument has much to recommend it.

* W. Guertler, "Ein Neues Metallmikroskop," *Metallurgie*, 1909, VI., 651.

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POWER IN ITS RELATION TO THE INDUSTRIES.*

By CHARLES E. LUCKE.

Recorded or unrecorded history, the story of things that have happened, with explanations of the probable reason, may be regarded as a most useful, if not a necessary guide to the conduct of present day affairs, whether it be concerned with wars and governments, or the customs and mode of living of the people; whether written in books carrying the title of history or told by the old to the young; treating of ancient times or the events of yesterday. For a long time writers of history were content with records of armies and battles, and their relation to the fall of one empire and the rise of another. Little, if any, attention was given to such ordinary questions as the sort of food the people ate, the kind of clothes they wore, of what sicknesses they died, at what occupation they labored and with what tools to assist them, what compensation they received and how the product of their labor was obtained by the non-producer; all of these questions of far more vital importance to the welfare of the average individual than the quarrels of nations. While some little information of this class may be found in general literature, not ordinarily classed as history, the topics there discussed seldom refer to the daily work of the mass of the people, by means of which the whole population was fed, clothed and housed, or the relation of these questions now generally classified as industrial, to the social or governmental organizations, the welfare of the individual, or changes of state. Modern historians, however, are waking up to the fact that present conditions have been brought about not so much by the victories of war as by the practice of everyday acts of peace, and that a dia-

*This is the first of a series of eight Hewitt Lectures delivered at Cooper Union before an ordinary, non-technical audience. The presentation, therefore, has been kept as elementary as was consistent with the audience and nature of the subject. The object of the series was to arouse public interest in the work of engineers. The whole series is to be published under copyright by the Columbia University Press in book form in the fall.

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gram of a loom for weaving cloth may really be a more valuable thing to study than a map of the battle of Waterloo.

There seems to be little doubt now that industrial conditions are of primary importance in shaping the various conditions of human affairs, and are fundamental to the mere existence of government, but this did not appear so clearly in early times. In the days when the great body of the people were farmers, when little mining was practiced and practically no manufacturing, about the only unusual or extraordinary happenings were the wars, so it is not surprising that a history of the period should be a record of these conflicts. Later on, however, things changed, industrial affairs assuming more importance as factories were built, drawing men from farms and concentrating them in factory towns, and stimulating the development of steamships and railroads to bring raw materials to the factories and to distribute their products, giving more and varied employment to others and supplying all with new forms of the necessaries and luxuries of life, and completely changing the whole social organism. The great change in conditions, which made these things which formerly seemed all-important assume minor significance, and accented the truly greater importance of industrial affairs, began a little over a century and a half ago with the invention of the spinning and weaving machinery and the steam engine to drive it. Tracing from that time the progress of the substitution of mechanical power and machinery for hand labor, by which these things that people want can be produced better and cheaper than ever before, as well as new things previously not thought of, but which are wanted as soon as seen, will serve to explain modern conditions as no other study can. Instructive as such a review of industrial history may be, it is as nothing compared to the value of an understanding of the industrial conditions of the present time. It is far better to know how a hat is made, a trolley car works, or the fruit of California can be sold cheaply in New York, three thousand miles away, than any of the facts of history, though the latter may precede and make easier the comprehension of the more complex present. Referring to the importance of these industrial changes which is slowly but surely becoming accepted as it should be, is a well-worded statement in Robinson and Beard's "Modern Europe."

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"The study of mechanical invention is in no way inferior in fascination and importance to the more familiar history of kings, parliaments, wars and constitutions. The chief factors in it never stirred an assembly by their fiery denunciation of abuses, or led an army to victory, or conducted a clever diplomatic negotiation. On the contrary, their attention was concentrated upon the homely operations of every-day life; the housewife drawing out her thread with distaff or spinning wheel, the slow work of the weaver at his primitive loom, the miner struggling against the water which threatened to flood his mine. They busied themselves perseveringly with wheels, cylinders, bands and rollers, patiently combining and recombining them until after many discouragments they made discoveries destined to alter the habits, ideas and prospects of the mass of the people far more profoundly than all the edicts of the National Assembly, or all the conquests of Napoleon taken together."

The often heard characterization of our times as the "industrial age," and of our most influential citizens as "captains of industry," are indications of growing respect for the manufacturing and transportation industries not merely as occupations or means of employment, but as world-shaping forces stronger than armies and navies, and marks of appreciation of the fact that the training of engineers is more important than that of generals. It is not so generally realized, however, that all this would be quite impossible without power-generating machinery, which, receiving the water of the river or the heat of fuel as sources of energy, changes them under man's control and finally turns the wheels of industry.

It is difficult to believe that anyone with ordinary natural curiosity, after having his attention drawn to these facts and knowing that practically every article that he uses, especially in cities, is power-produced at least in part, can fail to inquire how it was brought about; in just what way man has succeeded in harnessing nature to do his will; for the employment of power-generating machinery is a demonstration of his control over those forces of nature that once struck fear into the hearts of men by lightning, fire and flood.

When, in addition, it may be promised that an examination of the power-generating processes and machinery on which so much

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of general interest and personal welfare depend, will also reveal the working of broad, philosophic law applicable to all human affairs with profit, the systematic location and reduction of waste in all things, then mere curious questioning may well be expected to yield to enthusiastic study.

We are every moment surrounded by manufactures and results of mechanical power and driven machinery in almost infinite variety. Not only are the clothes, hats and shoes we wear produced by power-driven machinery, at least in part, but so also are all the fabrics of the household, linens, carpets and hangings, the furniture, glass, chinaware and metal house furnishings, and practically all that enters into the making of the house itself, cement, brick, pipe, nails, furnaces, radiators and lamps.

In addition we use power-generated electric light and bathe in power-pumped water, ride in powered cars and boats, make war with power-made guns, and ships consisting of several million dollars' worth of machinery each. The very food of our tables is drawn from the waters, forests and farms of the earth by highly developed systems of transportation, preserved by machine processes or stored between production and need in power-cooled refrigerators, and we cool our beverages by manufactured pure ice.

In order that we may just exist we require a supply of food and clothing, while comfortable living adds the necessity of housing with heat, light and water, finer clothing and more choice food. To supply the necessities, comforts and luxuries of present-day life requires a more complex series of operations by men with knowledge of nature's stores, and of the means by which they can be brought from the hidden places at the extremes of distance, and changed when necessary to that form which may be desired. Seldom are nature's stores of substances found in suitable form for use; but man early learned to change their form by hand, and devised tools to assist in the cutting of stones, the weaving of grasses and fibrous wool of animals into cloth; and later to use natural energy to assist, by baking clay to form bricks and pots, and by heating certain rocks to get copper and iron, though for a long time there was no realization of the fact that the use of fire to assist change of form was a demonstration that heat was one kind of natural energy, or that it could be made to do common work of lifting, pushing and pulling.

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A still earlier though similarly unconscious use of heat energy was made when man planted seeds in the earth to obtain a supply of food. These seeds grew and in the growing the substances of the earth into which the seed was placed, together with the air and water, which surrounded it, were transformed into the potato and the tree by the chemical and molecular forces derived from the energy of the sunshine, binding up the sun's energy in the new plant form taken by the primary inanimate substances. This change of substance form through the assistance of natural energy, by which the useless may be made useful, and of which life itself is the best example, taught a lesson unlearned through countless ages, during which but little progress toward what we are pleased to term "civilization" was made. No one dreamed that energy was being used, or even that there was such a thing, in those days, and it is not too much to say that the conception of energy which recognizes heat, work, electricity, magnetism, sound and light as interchangeable energy manifestations, was one of the most significant in point of results that the world has ever seen.

The discovery that energy was available in nature for the doing of man's work is sometimes traced to his natural indolence when he placed sails on boats, and paddle wheels under waterfalls to lift weights, even though no idea existed that the capacity of the moving water and moving air do these things was proof of the existence of energy in nature, and exactly similar to the capacity of a fire to melt things or extract metals from ores.

From the practice of these simple processes of form changing, such as weaving and the application of wind and water energy to the service of men, there is a long period during which no real progress worth mentioning was made, and which came to an end only with the general realization, first, of the possibility of devising combinations of sticks and metal parts to reproduce the movements of hands and fingers and eliminate the guidance of the eye, in short to make things wanted from other things available, and secondly, that the heat of burning fuel, if properly applied to other substances and metal parts, was capable of doing the same sort of work as the waterfall and the wind.

The general process of changing the useless things into useful and more useful things, is termed to-day "manufacturing," when

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carried out systematically and repeatedly in the same way, while the processes by which natural energy of whatever form can be made to do man's work is called somewhat incorrectly "power generation." Together these processes of manufacturing and the generation of power, carried out in the machinery of manufactures, perform the function of changing natural things into other things that people want; so man has learned in part nature's own lesson of organic life and applied it to his needs and pleasures.

Culture and the full enjoyment of life are possible only when the demands for the necessities have been satisfied; or, speaking more broadly, national prosperity is a necessary prerequisite to civilization, and that nation is most permanently prosperous in which production of wealth is the more universal occupation; wealth derived primarily from the farm, the sea, the mine and the forest, the raw materials of which are augmented in value by manufacture, giving rise to transportation and commerce. In all of these industries, basal to national security and happy living, mechanical power plays a part, more important in some than in others, but an important part in all. Practically all our fish products are gathered in power boats to-day; mines that can raise the ore to the surface without power are rare, and still more rare are the ores that can be reduced to metal without it; the farmer is resorting more and more to power, one manufacturer alone last year having sold 30,000 gasoline engines for farm use. It is, however, the other two industries that are most dependent on power; manufacturing owes its very existence to our ability to generate, apply and control power economically, while power is the prime element in transportation over land and water. These two great businesses of making things and moving them, now classified as the industries of manufacturing and transportation, underlying practically all of commerce, owe their present state to power and their future is largely a power problem.

Clearly as does a review of these things indicate our dependence on the use of power applied in the industries, it will be helpful in reaching a measure of the magnitude of the interests involved to examine some statistics drawn from the last census reports for the year 1905. From these reports it appears that the manufacturing and steam-railroad industries alone represent a capital

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valuation of nearly twenty-four billion dollars, about equally divided. The railroads of the country alone represent a mileage of 213,932 miles, or enough to go eight and a half times around the earth, while the manufacturing industries reported over two hundred thousand establishments. These together gave employment to nearly eight million people, about six million in manufacturing and over one and a half million on the railroads, paying them on the average of $640 each on the railroads, and $550 in the manufacturing classes, the manufacturers' payrolls aggregating over three billion dollars ($3,186,301,763) yearly. Raw materials from mine, farm, forest and sea used by the manufacturers cost them over eight and a half billion dollars ($8,503,949,756), and the processes through which they were transformed increased their value about 70 per cent., adding to the wealth of the country over six billion dollars, the manufactured goods becoming worth nearly fifteen billion dollars ($14,802,147,087). These industries now employ power to an extent approaching $50,000,000 horse-power, not all of which is reported, but for each horse-power that is reported the products were worth $1,152, and $248 in wages were paid in the manufacturing industry. The present total is estimated from the following figures, Table I., which do not include automobiles, hoisting, pumping and compressing engines, and independent engines used in buildings not engaged in manufacturing, such as hotels, which should be added, and which would considerably increase the reported total, while the total to-day must be much increased over the census year of 1905, as the rate at which the use of power has been increasing has been itself on the increase since the Civil War.

TABLE I.

POWER IN USE BY LAST CENSUS, CORRECTED BY H. ST. CLARE PUTNAM.

Manufactures (1905)	12,765,594
Mines and quarries (1902)	2,753,555
Street railways (1902)	1,359,289
Electric light and power stations (1902)	1,845,048
Telephone, telegraph and fire alarm	3,148
Custom flour, grist and saw mills, and industries omitted from census	883,685
Naval vessels (1905)	777,598
Licensed merchant vessels (1905)	2,608,270
Locomotives (1904) equivalent	3,750,000
Total horsepower accounted for	26,745,187

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In reporting the manufacturing industries many establishments were omitted in accordance with the bureau's definition of a factory as "an establishment in which there is an association of separate occupations to facilitate the combination of the processes into which the manufacture is divided, and producing goods for the general market stock rather than on the order of an individual." This includes the small shoemaker, milliner, all the building trades and similar kinds of business.

The greatest manufacturing industries may be judged by either the number of wage earners or the value of the products, and on this basis the following two tables are offered, from which it appears that each of five groups of industries employed over two hundred thousand wage earners, and each of six industries produced goods valued at half a billion dollars or more.

TABLE II.

GREAT INDUSTRIES BY WAGE EARNERS. INDUSTRIES EMPLOYING OVER 200,000 WAGE EARNERS.

Industry.	Number of Wage Earners.
Lumber and timber products	404,626
Foundry and machine shops	402,916
Cotton goods	315,874
Steam railroad shops	236,900
Iron and steel works and rolling mills	207,562

TABLE III.

GREAT INDUSTRIES BY VALUE OF PRODUCTS. INDUSTRIES WITH PRODUCTS WORTH A HALF BILLION DOLLARS YEARLY.

Industry.	Value of Products Yearly.
Slaughter and meat packing	$801,757,137
Foundry and machine shops	799,862,588
Flour and grist mill products	713,033,395
Iron and steel works, rolling mills	673,965,026
Lumber and timber products	580,022,690
Cotton goods	450,467,704

To supply the manufacturing industries with raw materials there are supported the other industries of lumbering, mining, farming and fishing, each of which contributed, as shown in Table IV.; over 94 per cent. coming from farms and mines.

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TABLE IV.

SOURCE OF RAW MATERIALS AND THEIR DISTRIBUTION.

Source.	Yearly Value.	Per Cent.
Farm	$2,492,836,646	81.2
Forest	163,464,677	5.0
Mine	471,118,181	13.4
Sea	13,715,086	.4
	$3,141,134,590	

FARM PRODUCTS.

	Per Cent.
Food products industry	63.6
Textile industry	18.6
Leather goods industry	6.4
Liquors and beverages	2.4
Chemicals	3.9
Tobacco	4.0
Miscellaneous	1.1

SEA PRODUCTS.

	Per Cent.
Food products	83.1
Chemicals	1.9
Miscellaneous	15.0

MINE PRODUCTS.

	Per Cent.
Iron and steel goods	23.9
Chemicals	33.9
Clay, glass and stoneware	5.3
Other metal products	29.8
Miscellaneous	7.0

FOREST PRODUCTS.

	Per Cent.
Lumber products	53.8
Paper and printing	15.6
Chemicals	5.6
Vehicles	1.6
Miscellaneous	24.0

Not only does the manufacturing process add to the wealth of the country by increasing the value of the materials used nearly eighty per cent. but it also gives a value to the raw materials which they did not previously possess in their original state. There would be little demand for iron ore without the means of extracting the iron and making of it things that people want; fruit, vegetables and fish are produced at definite seasons and are worth more since means of preservation and cold storage were developed than before; the machinery for making shoes has so increased the demand for shoes as to give increased value to hides, or an equal value to more of them. Coal tar was once an annoying by-product of gas works, but is now a source of medicine, beautiful dyes and perfumes; cotton seed has become valuable as the source of a useful oil; in 1860 it was garbage, in 1870 a fertilizer, in 1880 a cattle food, in 1890 a table food. Certain parts of animals slaughtered for meat were once annoying waste; now every part is utilized, and from the former waste by-products are made gelatine,

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glue, brushes, oils, buttons, medicine and soap. What was once useless has been made useful, and that which had value has been

FIG. 1.

given ever-increasing value by manufacture, so that the prime producing industries of farming, fishing, mining and lumbering, may

FIG. 2.

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be said to be largely supported by the manufactures, transportation being the connecting and similarly dependent industry, and of this complex organism the vital organ is the power plant without which the operating machinery would be lifeless and impotent.

In trying to realize the strides that have been made, which is the first step in the appreciation of our present situation, it will be

FIG. 3.

helpful to look at some pictures, in addition to studying the figures which tell the story of the magnitude of industries practically non-existent before power became available. In those days there was nothing but the wind-mill and water-mill, such as are shown in Figs. 1 and 2, and about all they did was to grind grain, lift hammers, or blow bellows for furnaces; boats were small and moved by sails, and land transportation was dependent on the horse. Compare these illustrations of the old conditions with the following illustrations of the present. The picture, Fig. 3, shows the exterior of the New York Subway power-house, occupying a whole block, with a capacity approaching a hundred thousand horse-power, and filled with seemingly complicated machinery, as will be appreciated from the interior of one half shown in Fig. 4.

This power station, while the largest, is only one of hundreds of

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similar ones located in every city in the country. The modern steamship, "Kaiser Wilhelm," in front of New York city, shown in Fig. 5, would have been no less wonderful or unreal to the owner of the old windmill, or to the captain of the small sailing vessel of those days before the steam engine, than would a vision

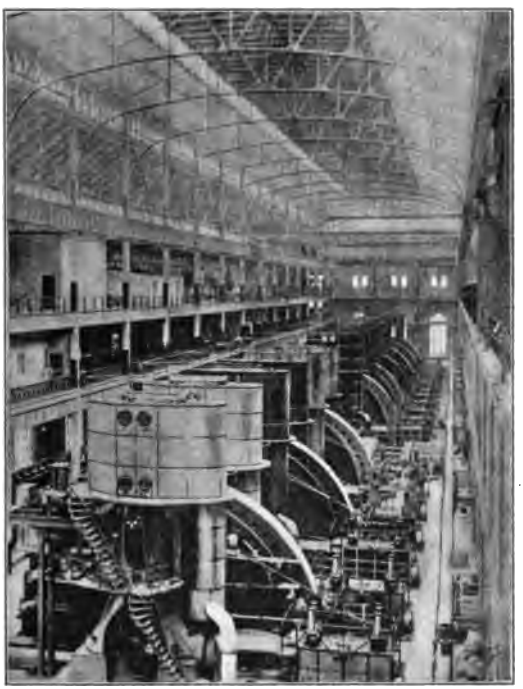

FIG. 4.

of heaven. This vessel, some hundreds of feet long, carries deep down below the waterline a large steam-power plant, plainly shown in the sectional view, Fig. 6, with nineteen boilers, each seventeen feet in diameter and shown in Fig. 7, supplying steam to ten engines of nearly fifty thousand horse-power, the size of which is clearly indicated in Fig. 8, by the man standing in the center of the picture.

No less impressive is the comparison of the old horse and wagon as the sole dependence for moving goods on land with a modern locomotive, one of the latest and heaviest of which for the Erie Railroad, is shown in Fig. 9, a complete steam-power plant in

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itself, capable of drawing across the country half a hundred cars, each carrying fifty tons of coal, at high speed, and another, for the New York Central, shown in Fig. 10, which is capable of drawing a heavy ten-car Pullman train over a mile a minute, making pos-

FIG. 5.

sible a journey to Chicago, of about nine hundred miles in eighteen hours, maintaining an average speed, including stops for coal, water, switch, signals and stations, of fifty miles an hour. There are no statistics of steamship transportation available, but the railroad business, so largely supported by the manufacturing industries, is fairly well determined, and included in 1900 a passenger mileage of over one and a half billion miles, or over two

FIG. 6.

hundred miles per capita of population, while the freight haulage was equivalent to one hundred and forty-one billion six hundred million ton miles (one ton hauled one mile).

Just as is the comparison of the pictures of the modern power plants with the old wind- and water-mills useful, so is a brief survey of a few of the characteristic establishments of the larger manufacturing industries, which did not exist at all before the

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advent of the steam engine. Some of these establishments employ hundreds and even thousands of men, and constitute with the homes of the workmen, the stores and homes of tradesmen who supply them, fair-sized cities in themselves. The greatest manufacturing groups are of food-stuffs, iron and steel products, and textiles, and the following pictures of one establishment of each class will serve the purpose. The slaughter houses, meat product factories, and cold storage warehouses of Swift & Co., at Chicago, in which over ten thousand horse-power is used, are shown in Fig. 11; the Homestead Works of the Carnegie Steel Co., at Pittsburgh in Fig. 12; the machine shop of the Allis-Chalmers Co., at

FIG. 7.

Milwaukee in Fig. 13; and in Fig. 14 is shown the largest cotton mill in the world, located at New Bedford. This mill can house over five thousand looms for weaving cloth and one hundred and fifty thousand spindles for making the necessary thread, all of which require some ten thousand horse-power to drive. The appearance of a spinning room showing the rows of spindles on the machines is shown in Fig. 15.

In round numbers eighty-five per cent. of all the power last reported in use in this country for manufacturing is derived from the combustion of fuel in steam boilers, which deliver steam to engines and other apparatus capable of producing mechanical motion, and in the case of locomotives and steamships nothing but

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fuel-burning steam systems are in general use. About fourteen per cent. of the power generated on land for stationary use is derived from falling water, and about one per cent. from fuel turned into gas, mixed with air and exploded in gas engines, so that practically eighty-six per cent. of the power in use on land, and all of that in use by railroads and steamships, are derived from

Fig. 8.

fuel sources, and the remainder from natural streams. Fuel in some form is then our principal source of natural energy to-day and is becoming increasingly our main dependence, as the percentage of power derived from streams has been continuously decreasing for forty years. While the natural fuel may vary from hard, glossy anthracite coal through various grades of soft coal

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FIG. 9.

FIG. 10.

FIG. 11.

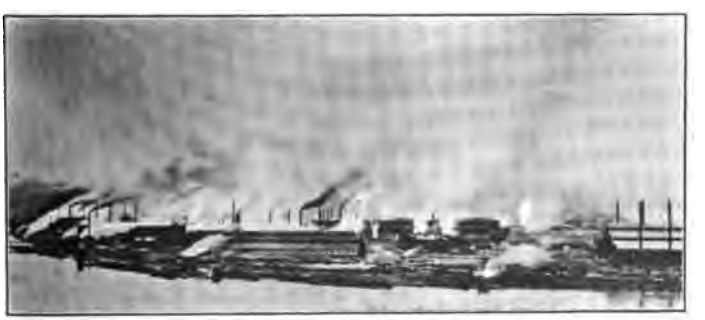

FIG. 12.

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to spongy peat in the solid fuel class, and through various oils in the liquid class to natural gas, all can be traced to sun-grown products that have died and become packed together beneath earth and rock. The source of the energy of these fuels then seems to

FIG. 13.

be traceable in turn to the heat of the sun which produces the plant growth, and it is likewise the sun that evaporates water from the ocean, forming clouds, which are driven by sun-produced winds over the cold places, condensing the vapor into rain, which falling on high places produces rivers and water-falls. Fuel, flowing river-water, or the winds themselves, all owe their energy to the sun, each manifesting its energy in its own peculiar way, and re-

FIG. 14.

quiring a corresponding variety of machines to enable each form to do the same work at will. It has been estimated (Putnam) that the rate of increase in using power since 1870 has been such as to double the amount every ten years, shown in Fig. 16, and this same rate of increase applies as well to coal production, railroad

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gross earnings, freight ton mileage, passenger mileage, and value of agricultural products, proving absolutely the direct relation and dependence of the industries on power, and how serious will be the effect of lack of available power to meet the demands of industrial progress.

Coal is the main fuel dependence now and there was produced in 1907 about 450,000,000 tons; the railroads alone used in 1906 90,000,000 tons for which was paid $170,000,000. At the present rate the known supply of anthracite will be exhausted in about

FIG. 15.

70 years, but the bituminous supply will last longer. It is estimated by E. W. Parker, of the U. S. Geological Survey, that if the present rate of increase continues for 150 years and the consumption then becomes constant the supply will last 700 years. Similar estimates place the water power capacity of our streams at 30,000,000 H.P., of which only ten per cent. is now used. So long as these natural supplies are depended upon great care must be exercised in preventing waste, but it must be remembered that millions of square miles of land, especially in tropical countries, can be put under cultivation to produce wood for fuel, or the more rapid-growing substances like sugar cane, sorghum, corn, or potatoes bearing starch or sugar, which can be converted into alco-

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hol in never-ending supply. Just what fuel is to be used and by what system of machinery now or in the future, and whether fuel or water power, will depend on the cost of the power by the system, which is a negative measure of waste. That source of energy and system of machinery that produces power with the

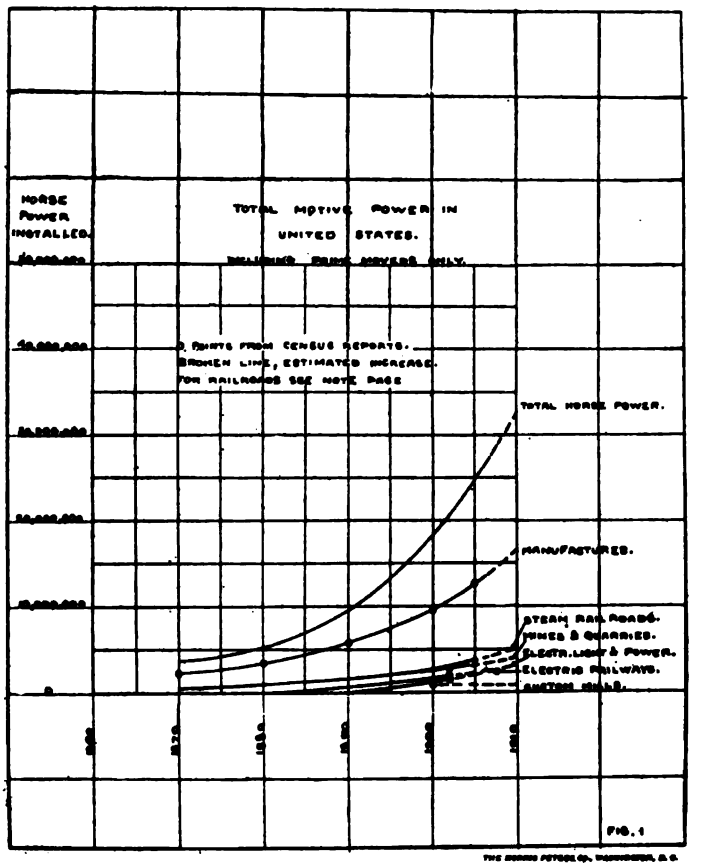

FIG. 16.

least net waste is the one that will be used; least waste of energy, of man's labor, of wear in machinery, and of investment, all together, and the prediction of the industrial future of the country, which in turn so powerfully influences its social and economic welfare, reduces to a study of waste reduction.

By making studies of nature's substances and nature's stores

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of energy, and evolving means of using the latter to do the work of transporting the substances which are to be or have been changed to useful forms by similar power-driven machinery, not only has the wealth of the country been enormously increased and the general average of living likewise been raised, but direct employment has been created for ever increasing millions of population as wealth producers and traders in goods produced. The success of industrial undertakings, dependent as it is primarily on the economic use of power, is, however, and always will be impossible without men, men of every walk of life, every degree of physical strength, mental power and education. Equal as men may declare themselves to be before the law in their claims of rights to live without annoyance from others, no sane man can believe they are equal in attainments, or that the attainments of any one may not be increased by study, training and experience. Were we all farmers or all weavers of cloth there would be no possibility of finding an occupation for each, best suited to his ability, but the creation of these varied industries has had the effect of diversifying the duties of the army of men necessary to conduct their affairs. There is now work to be done in infinite variety and of different degrees of difficulty, so that the most ignorant man may find a useful place in the same establishment with the one most richly endowed with brain power developed to the maximum by education and experience, and capable of directing its affairs which are often more complicated and difficult to administer correctly than those of state government.

To make a watch requires a very large number of processes on many separate pieces of metal; for each process tools and machines are devised and men trained to be skillful in their use; other men must buy the metal and the tools, sell the watches made, keep the factory in repair, keep records of cost, answer letters, secure money for payrolls, decide how many watches of each style shall be made, far in advance of the time they will really be wanted. Each man must work in definite relation to the others or the result will not be attained; so that the relation of the men to each other and to their tools and machines must be similar to the relation existing between the parts of the watch, even in spite of the fact that each man is human and is endowed with feelings and

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human perversity. The adjustment of these human relations to form the human machine, called the organization, is just as necessary in one kind of industry as in another, and applies universally to all individual establishments; without organization there would be no effective or economic manufacturing or transportation. The organization is the result of the attempts to reduce waste of human effort, such as results when one man has to repeat the work of another, or when one man opposes the efforts of another, or when anyone is idle or fails to produce as much as he can. The systematic study of reduction of waste of labor, by management and organization systems, is a comparatively recent thing, undertaken only after years of effort in reducing waste of energy in power machinery, and waste of substances not in available form, but which could be made into new and useful forms by persistent trial. That men properly organized, trained, assisted and properly paid, can produce effects enormously greater than many times the same number of unorganized individuals, especially when assisted by capital, is a basal proposition of the industries, which we were as slow in learning as we were the lesson that nature's energy might be made to do man's work. It really seems as if the methods learned in applying nature's orderly laws controlling the generation of power and its application to machinery, are to be the means of teaching us how best to get along with each other, to work in common to produce desired results with the least waste, as effectively and harmoniously as do the parts of the press that prints our daily papers.

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ABSTRACTS—ANALYTICAL CHEMISTRY.

By E. WALLER.

Zirconia crucibles Weiss and Lehmann (*Z. anorg. Chem.*, LXV., 178). ZrO_2 obtained from Brazil zirconite was found to be a good material for the manufacture of crucibles when fused in the manner adopted for making quartz or silica apparatus. It is more difficult to melt. Crucibles were made from a mixture of 9 parts pure ZrO_2 with 1 part MgO and 10 per cent. phosphoric acid. The coefficient of expansion is very small, and sudden changes of temperature have no destructive effect. Fused alkalis or bisulfates were also practically without effect.

Substitute for Platinum Wires in Qualitative Work. Kirby (*C. News*, CI., 170). Select a few threads of asbestos about 12 cm. long, moisten with solution of H_3PO_4 (one of acid to one or two parts of water) and heat them gently in the Bunsen flame, to drive out the most of the water, leaving them still plastic. Then roll them between the fingers to form a smooth filament. Heat up carefully at first, finally in a strong blowpipe flame. Though somewhat brittle these "wires" are very serviceable for flame tests, bead tests, etc. When clean they impart no color to the flame. They may be dipped in water or dilute acids and except when in prolonged contact are not disintegrated.

Cupferron, a New Reagent. Baudisch (*Chem. Ztg.*, XXXIII., 1298). The substance is ammonium-nitroso-phenyl-hydroxylamine and in presence of excess of HCl causes quantitative separation of Fe and Cu from all other metals except Pb and Ag, which are partly precipitated. The reagent is white and crystalline, freely soluble in water, slightly decomposable by the action of light.

The complex Fe or Cu compounds in the precipitate are but slightly attacked by $2N/HCl$ in the cold but readily decompose on heating. Cold dilute Na_2CO_3 has no effect but solutions of the caustic alkalies decompose them immediately. NH_4OH decomposes the Cu compound but not the Fe.

As may be inferred the reagent should be used at ordinary temperatures in fairly strong acid solution and the precipitate should be filtered off quickly.

Alkali Bicarbonates in Presence of Carbonates. Löwinger (*Chem. Ztg.*, XXXIII., 1174). Add a measured amount of standard NaOH more than sufficient to convert all bicarbonate to monocarbonate, and then an excess of $BaCl_2$. Then without filtering titrate the excess of NaOH by standard acid.

The standard NaOH used for the purpose must be strictly free from monocarbonate. If there is any reason for doubt on this point, it should be tested in the same manner—by adding excess of $BaCl_2$ and titrating—and if necessary the correction applied.

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Sodium, Cæsium and Rubidium, Qualitative. Ball (*J. Lond. Chem. Soc.*, XCV., 2126). Potassium bismuth nitrite solution [$Bi(NO_2)_3$-$3KNO_2.H_2O$] containing about 1 per cent. $CsNO_3$ gives a yellow precipitate with very minute amounts of Na salts having the composition $9CsNO_3$, $6NaNO_3$, $5Bi(NO_2)_3$, Ag. Co, and many other metals also give precipitates. Conversely, sodium bismuth nitrite constitutes a good test for Cs, and also for Rb if not too much diluted (beyond 0.5 per cent.). In testing, the solutions should be acidified with HNO_3.

Lime—Caustic in Presence of Carbonate. Heyer (*Chem. Ztg.*, XXXIII., 1159). Free NH_3 diminishes the solubility of $CaCO_3$ in NH_4Cl, and in the method depending upon treating the sample with cold dilute solution of NH_4Cl and subsequent determination of dissolved CaO, the proportions should be so arranged that the mixture should contain at least 1 gm. NH_3 per 100 c.c.

Calcium Carbonate in Soils. Marr (*J. Agric. Sci.*, III., 155). Boiling with acid (HCl or H_2SO_4) and determining the CO_2 evolved, gives results which are too high if the proportion of humus is large. The use of a more dilute acid, or working under diminished pressure, or both, will afford results much more nearly correct.

Manganese in Steel—Colorimetric. Auchy (*J. Ind and Eng. Chem.*, I., 813). In applying the method depending upon oxidation of the HNO_3 solution by Pb_3O_4, low results are usually obtained, as a result of the reducing action of the C in the steel. To avoid this, the author uses the solution from treatment of a weighed amount of the steel (2.351 gms.) with H_2SO_4 and evaporation to strong fumes. After dilution and boiling, the filtrate and washings are made up to 200 c.c. 25 c.c. are then taken out, mixed with nearly 25 c.c. of HNO_3 (of 1.2 sp. gr.), boiled 15 minutes, removed from the heat, Pb_3O_4 added and stirred in, then diluted to the mark and stirred again. The $PbSO_4$ and excess of PbO_2 settles out quickly, and the color comparison with solution from a standard sample can be readily made.

Zinc in Presence of Iron—Rapid method. Taylor (*J. S. C. I.*, XXVIII., 1294). In a solution perfectly neutral, H_2S precipitates Zn, affording a corresponding amount of free acid, which can be titrated with *N/2* $NaHCO_3$. Ferrous solutions fail to show any sulfide until the neutral point is passed.

On this basis the plan to be pursued is this: About 10 c.c. of the solution containing the Zn is neutralized exactly by use of $NaHCO_3$ using methyl orange as indicator. Add 20 c.c. of a saturated solution of NH_4Cl. Then 100 c.c. of saturated H_2S water is added. Then *N/2* $NaHCO_3$ is run in slowly with agitation. As the end point approaches, the precipitate begins to show a gray color. When a decided chocolate color is obtained, the titration is finished. At the start, if each drop of the $NaHCO_3$ solution does not show momentarily a black spot as it strikes the liquid, the amount of H_2S is insufficient. When standardizing it is necessary to add a little neutral $FeSO_4$ to the solution to act as indicator. Naturally, Pb, Cu, and other members of the H_2S group must be removed before proceding to neutralize preliminary to titration.

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Nickel in Nickel Steel. Rhead (*Analyst*, XXXV., 97). The point investigated was chiefly the separation of the Fe. (In all cases brought to ferric form.) Basic acetate separation. The solution must be neutralized beyond the point where the strong coloration begins to show, indicating solution of $Fe_2(OH)_6$ in the ferric solution. Before adding the acetate, but little turbidity should be visible. 5 to 10 gms. of alkaline acetate, and a few c.c. of acetic should then be added. Na acetate gives more certain results than NH_4 acetate. A large excess of acetate or long boiling gives a slimy precipitate difficult to filter. One minute boiling was found to be sufficient.

In the basic acetate manipulation or in precipitation with alkalies any temporarily localized precipitation in any part of the solution tends to hold Ni in the precipitate, hence alkali or alkaline acetate is best added in dilute solution when near the point of precipitation, and also persistent stirring is necessary.

The NH_4OH separation was found to be imperfect and uncertain; chloride solution gave the best, sulfate the worst, results.

NaOH (eventually in slight excess), together with about 6 times as much KCN as would suffice to form $K_2Ni(CN)_4$, gave excellent separations.

NH_4OH instead of NaOH with the cyanide was less satisfactory. In the filtrate the Ni was best separated by Br and NaOH.

The quickest method, affording complete separation, was that of Iwanicki with dimethylglyoxine in NH_4OH solution. About 7 times as much dimethylglyoxine as Ni present should be added.

In electrolytic depositions of Ni the presence of chlorides was found to have a retarding influence.

Iron Titration. Joseph (*J. S. C. I.*, XXIX., 187). "Moderate accuracy" may be attained by acidifying the solution with HCl, adding a few grammes of KI, and titrating at once with standard $Na_2S_2O_3$. If the material is insoluble in water the addition of a little $KClO_3$ when dissolving in HCl, may be necessary to obtain all the Fe_2 as ferric. Of course in such a case the solution must be boiled down to destroy all excess of oxidizer.

Great accuracy may be attained by methods described in Treadwell's "Analytical Chemistry" or Sutton's "Volumetric Analysis."—Nearly neutralizing free HCl, filling the flask with CO_2 and allowing to stand before titrating.

Chromium in Steels—Rapid method. Randall (*Metal and Chem. Eng.*, VIII., 17). Dissolve 1 gm. in 25 c.c. of a solvent made up as follows:

HNO_3 (conc.)	300 c.c.
H_2SO_4 (1:3)	300 c.c.
H_3PO_4 (85 per cent.)	100 c.c.
Water	300 c.c.
$MnSO_4$	1.5 gms.

Dilute with 15 to 20 c.c. of water, swirl about, while adding 1 gm. sodium bismuthate, keep up the agitation for a few seconds, and then boil vigorously. The first effect is the formation of permanganic acid,

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which by continuing the boiling converts Cr to CrO_3. Decompose any excess of manganic compounds by adding a little HCl and boiling for about one minute. Cool—dilute to 200 c.c., add a known amount of standard ferrous ammonsulfate (in excess) and titrate back with standard permanganate. It is stated that accurate results can be obtained in 10 minutes.

Chromium Oxide—Precipitation by Aniline. Schoeller and Schrauth (*Chem. Ztg.*, XXXIII., 1237). The Cr_2O_3 solution should be neutral, and diluted to 300 c.c. which should not contain over 0.1 to 0.2 gm. of the metal. Heat to boiling, and add three successive doses of 1 gm. each of aniline. Continue boiling for 5 minutes, let stand on the water-bath for 5 minutes more, and wash by decantation. The method serves to separate Cr from Mn but not from Zn.

Separation of Cerium. Browning and Roberts (*Am. J. Sci.*, XXIX., 45). Mosander's method of separating cerium from other allied earths by suspending in alkaline solution, and passing in Cl, is well known. The authors have found that Br can be used instead of Cl with great advantage. The separation is more readily managed, and so many repetitions of the treatment are not required as in the use of Cl.

Molybdenum in Molybdenum Glance. Collet and Eckardt (*Chem. Ztg.*, XXXIII, 968). Fusion with alkali and nitrate seldom effects complete decomposition. Error is also caused by the volatility of MoO_3 when igniting the sulfide to oxide. The method recommended is: Grind as fine as possible, and treat 0.3 gm. for 2 to 3 hours with fuming HNO_3. Evaporate off the excess, moisten with 1 or 2 c.c. conc. H_2SO_4 and heat practically to dryness without expelling all the acid. Take up with 50 c.c. of water, and filter. Wash with water, then with NH_4OH, then again with water. Add excess of NH_4OH, and filter off Fe_2O_3 and Al_2O_3. Concentrate to 200 c.c., remove Cu by $(NH_4)_2S$, and acidify and boil the filtrate which separates MoS_3. Evaporate the filtrate, expel the most of the NH_4 salts, take up with water, add $(NH_4)_2S$, again followed by HCl to recover the last of the Mo. Dry the precipitate, separate from the paper, which is then carefully incinerated, mix with S in a Rose crucible, heat in a current of H and weigh as MoS_2.

Titanium—Qualitative. Piccard (*Ber.*, XLIII., 4341). When Ti is in the trivalent condition pyrocatechin gives a much more marked yellow coloration than can be obtained with $H_2C_2O_4$. The test is more delicate than the H_2O_2 reaction, but is weakened by alkalies or their carbonates, and is prevented by mineral acids. The pyrocatechin must be present in excess.

Zirconia in Zirconite. Weiss and Lehman (*Zts. anorg. Chem.*, LXV., 178). The finely ground mineral is fused with 4 to 5 times its weight of $NaHSO_4$. Dissolve in water, and filter off SiO_2. Precipitate out any Pt from the crucible by H_2S. Evaporate three times to dryness, and heat to 110° to remove all SiO_2. From this expel SiO_2 by HF and add the ZrO_2 remaining to the main solution, after fusion with $NaHSO_4$. Nearly neutralize with NH_4OH, add excess of

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$(NH_4)_2C_2O_4$ and $(NH_4)_2C_4H_4O_6$. Warm and add $(NH_4)_2S$ to separate Fe. Keep warm for an hour, and then filter. Evaporate the filtrate to dryness, and ignite until white; fuse up with $NaHSO_4$, dissolve in water, add H_2O_2 and then NaOH to precipitate the Zr. Dissolve in HCl and reprecipitate with NH_4OH, for ignition and weighing, boiling out the excess of NH_3 before filtering off. In the NaOH filtrate the H_2O_2 can be destroyed by boiling, and the TiO_2 determined, after precipitation with NH_4OH.

Tungsten in Tungsten Steel. Wolter (*Chem. Ztg.*, XXXIV., 2). The steel need not be finely divided for attack by $KHSO_4$. Fuse 0.2 to 0.5 gm. with ten times as much $KHSO_4$, later add at suitable intervals two successive lots of $KHSO_4$, each as much as at first. Finally on heating to redness for 15 minutes the whole should be in quiet fusion and free from any undecomposed portions. Cool, boil with water, bringing the whole solution to 60 or 75 c.c. Add 20 c.c. conc. HCl, and boil, until the precipitate is a clear yellow. Keep on the water-bath for 30 minutes, then filter and wash with 10 per cent. NH_4NO_3. Then dissolve through into a weighed dish, evaporate and ignite. The filtrate is again evaporated to recover what WO_3 may have been held in solution. Heat for one or two hours at 120° to 130° C., add HCl and treat as before.

Tungsten—Volumetric. Kneckt and Hibbert (*Prof. Lond. Chem. Soc.*, XXV., 227). WO_3 is reduced by Zn in HCl solution to WO_2. This oxide is quantitatively converted to WO_3 by ferric compounds. The reaction may be stated as: $Fe_2O_3 + WO_2 = 2FeO + WO_3$.

The end-point is the disappearance of the blue color of the intermediate W compound.

Tungsten and Chromium in Steel. Hinrichsen and Wolter (*Zts. anorg. Chem.*, LIX., 183). Separation by HNO_3 gives low results for WO_3. Knowe's benzidine is also defective. The method preferred is: Treat 2 gms. of the sample with HNO_3 and evaporate down several times with dilute HNO_3. Ignite to decompose the nitrates, and fuse in Ni or porcelain crucible with Na_2O_2 (about 16 gms.). Dissolve in water and evaporate to about 150 c.c. to separate SiO_2, filter, and bring filtrate and washings to 250 c.c. In 50 c.c. acidify with HNO_3 and then add 10 per cent. NH_4OH until the precipitate becomes brownish black and the WO_3 is redissolved. In the filtrate from this precipitate WO_3 by use of $HgNO_3$. Cr is determined in a separate portion.

Vanadium—Colorimetric. Gregory (*Proc. Lond. Chem. Soc.*, XXV., 232). On mixing conc. H_2SO_4 solutions of V and of strychnine a violet color appears which changes to orange. The latter tint is permanent and is proportional to the amount of V present. Fe interferes, but Ti, W, or Mo do not.

Vanadium in Ores. Alvarez (*Chem. Ztg.*, XXXIII., 1149). Fuse 0.5 to 1 gm. with 7 to 8 times its weight of Na_2O_2, maintaining a red heat for 20 minutes. Extract with boiling water, acidify with H_2SO_4, add alcohol, and without filtering pass in SO_2 nearly to saturation. If necessary at this point, filter and boil out alcohol and excess of SO_2, assisting the process by passing CO_2. As if present can be removed

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by passing H_2S, the excess of which must be removed after filtering by boiling again. V in the solution may then be titrated with standard permanganate. (The solution should not contain over 1 per cent. of V.) The end reaction should not be regarded until the pink tint is permanent.

Vanadium. Watts (*Chem. Eng.*, X. —). Mix 0.25 to 1 gm. of the pulverized mineral with 3 gms. Na_2O_2 in a nickel crucible; cover with about 1 gm. more of Na_2O_2 and heat to dull red for 3 or 4 minutes. When darkening of the surface is complete, the fusion is finished. Dissolve (with some caution) in water (about 250 c.c.). Heat to boiling and pass CO_2 to saturation. Let settle, filter and wash with diluted Na_2CO_3 solution. Render the solution barely acid with HNO_3 —heat to boiling, add a little $NaC_2H_3O_2$ to neutralize the remaining HNO_3 and precipitate V by addition of $Pb(C_2H_3O_2)_2$. Filter off, dissolve in very little HNO_3, add 10 c.c. conc. H_2SO_4, and evaporate to fumes. Dilute and filter off $PbSO_4$. In the filtrate, reduce by boiling and adding Na_2SO_3. (About 1 gm. in small portions at a time.) Boil until the escaping steam will not reduce permanganate, and then titrate the hot solution with standard permanganate. Fe standard $\times 0.916 = V$.

A correction to the burette reading (usually about 0.2 c.c.) is obtained by boiling dilute H_2SO_4, adding Na_2SO_3 in the same manner as before, stopping when the steam does not reduce permanganate, and then titrating.

In case of the presence of much SiO_2, the filtrate obtained from the fusion, and filtration from Fe, etc., is slightly acidified with HNO_3, then made alkaline with NH_4OH, 3 to 4 gms. $(NH_4)_2CO_3$ added, and the mixture kept hot for about an hour. Then filter, and wash thoroughly with diluted $(NH_4)_2CO_3$. After that acidify with HNO_3 and precipitate with Pb salt as before.

Niobium and Tantalium. Weiss and Landecker (*Zts. anorg. Chem.*, LXIV., 65). Nb_2O_5 and Ta_2O_5 can be brought into solution by fusion with Na_2CO_3 and $NaNO_3$ and leaching with water; great excess of the fluxes should be avoided. Passing CO_2 through this solution precipitates Ta_2O_5 only. By repetition, a complete separation of the two can be effected. Another difference between the two consists in the reaction with K_4FeCy_6 in HCl solution, Nb gives a grayish green precipitate, Ta slowly forms a reddish brown precipitate; also in dilute H_2SO_4 solution the addition of concentrated $(NH_4)_2SO_4$ solution precipitates Ta but not Nb.

In extracting from minerals the material is fused with $KHSO_4$, and the Fe, etc., are dissolved out by use of dilute H_2SO_4 and boiling SO_2. Sn may be extracted by yellow $(NH_4)_2S$. Fusion with Na_2CO_3 and $NaNO_3$ will leave Ti in insoluble form, and from the solution Ta may be separated by passing CO_2 as above indicated. Several new points are brought out. A translation appears in *Chem. News*, CI., pp. 2, 13 and 26. In the last part, a detailed statement of the qualitative reactions of these earths is given.

Lead—Volumetric. Bollenback (*Chem. Ztg.*, XXXIII., 1142). The

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author has described a method previously (vide QUARTERLY, XXX., 53) in which 1 mol. $KMnO_4$ reacts with 3 mols. $Pb(NO_3)_2$. He finds that such occurs in presence of $CaSO_4$. In some other cases, the reaction was between 1 mol. and $3\frac{1}{3}$ (or 6 of $KMnO_4$ with 20 of $Pb(NO_3)_2$.) An excess of KNO_3 determines this form of the reaction. The modified method would therefore be conducted thus: Add 3 or 4 gms. KNO_3 and 5 c.c. of *N/2* NaOH to 300–400 c.c. of hot water. To this add a few drops of permanganate solution, and then run in standard $Pb(NO_3)_2$ solution drop by drop until the color is just discharged. Then add a measured amount of standard permanganate, in amount more than sufficient to react with the Pb to be determined, and then the solution of Pb in the form of nitrate. Titrate back the excess of $KMnO_4$ by use of a standard solution of $Pb(NO_3)_2$.

Lead Sulfate Separation. Kernot (*Rend. Accad. Sci. Napoli,* XV., 155). In treating ores containing Pb and Ba, after decomposing with acids and evaporating to fumes with H_2SO_4, treatment with $NH_4C_2H_3O_2$ to dissolve out $PbSO_4$ is applied. The author finds that variable results are obtained from the solvent action of the acetate upon $BaSO_4$. This varies with the concentration, being at a maximum (0.133 gm. per liter) when the concentration is at 300 gms. of the acetate per litre. Solutions either stronger or weaker than this dissolve less of the $BaSO_4$.

Small Amounts of Lead in Presence of Iron—Colorimetric Test. Wilkie (*J. S. C. I.*, XXVIII., 636 and XXIX., 7). The process is intended chiefly for application to such chemical products as citric or tartaric acid, which may have been treated in lead-lined tanks, etc. The presence of ferric iron completely destroys the value of the test by Na_2S, whether KCN is present or not. Reduction by Na_2SO_3 is only satisfactory in the absence of citric or tartaric acids. In their presence $Na_2S_2O_3$ only is efficient. The process is as follows: Dissolve a weighed amount of the material in water and acidify (with acetic or some other acid). Then add 1 c.c. of a 10 per cent. solution of KCN, and then an excess of NH_4OH. At this point the solution must be colorless. If such is the case, a few drops of Na_2S solution is added and the color comparison made. If, however, the solution is colored, it is probably due to Fe. If originally present as ferrous, heating to boiling will destroy the color, but if originally ferric, a fresh lot of solution must be taken. Acidify as before, and add a little *N/10* $Na_2S_2O_3$ solution, the amount depending on the proportion of ferric present. Heat slowly to incipient boiling, let stand until the color suddenly changes, and then add KCN and NH_4OH followed by Na_2S as before. The standard solution of Pb for comparison must be treated in exactly the same manner.

In the discussion the point was brought out that when comparisons are made with acid solutions, no further addition of Pb can be made to the standard after addition of H_2S, whereas with alkaline solutions, such treatment involves much less error. The use of sugar to intensify the color reaction gives no advantage when KCN is used.

Bismuth Sulfide—Solubility in Alkaline Sulfides. Knox (*J. Lond.*

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Chem. Soc., XCV., 1760). Bi_2S_3 was found to be perceptibly soluble in Na_2S or K_2S, the solubility rapidly increasing with the concentration, being approximately proportional to the cube of the concentration. Addition of the corresponding hydroxide to the sulfide solution considerably increased the solvent effect. In NaHS, KHS or NH_4HS it was practically insoluble. In Na_2S_2 the Bi_2S_3 was much less soluble than in Na_2S.

Copper—Volumetric. Sanchez (*Bull. Soc. Chim.*, VII., 9). In a neutral solution, KCN dissolves $Cu_2Fe(CN)_6$. The completion of the reaction is marked by a sudden change from the reddish brown of the ferrocyanide to a greenish yellow. The reaction is affected by the presence of Pb, Fe, Zn, Ni, Co, Mn or NH_4 salts. Sn, As or Sb are without effect. The Cu is brought into solution by HNO_3. Any Pb is removed by evaporating down with H_2SO_4. Cu is then precipitated out by means of $Na_2S_2O_3$. The precipitate of Cu_2S is dissolved in HNO_3, the excess of free acid boiled off as far as possible, and in an aliquot portion of the solution, the amount of standard alkali necessary to neutralize the remainder is determined with the aid of methyl orange indicator. After neutralization, solution of $K_4Fe(CN)_6$ is added, and the titration carried through by standard KCN (6.5 gms. per liter).

Arsenic in Copper. Azarello (*Gaz. Chim. Ital.*, XXXIX., 450). 5 gms. of the Cu in shavings or turnings is treated in a flask with conc. HCl in which has been dissolved 33 per cent. $Fe_2(SO_4)_3$. This is distilled, the vapors being passed through a vessel containing glass beads which is immersed in an oil-bath heated to 170°–175° before passing over into a condenser. The latter is pear-shaped, of pipette form, the tip dipping into diluted HCl (1:1) in a vessel surrounded by ice water. Boiling for about 55 minutes carries over all the As. The distillate is nearly neutralized with NH_4OH, then over-neutralized with $NaHCO_3$ (bulk 300 c.c.) and the As titrated with standard I and starch indicator, 0.4 c.c. is allowed for the amount of I solution required to give a coloration with the starch. The I solution contains 3.3858 gms. per liter, 1 c.c. = 0.001 As.

Antimony in Ores. Colbaugh and Betterton (*Eng. and Min. J.*, LXXXVIII., 209). Fuse in a glass flask with 8 or 10 times its weight of ammonium persulfate. Boil out with 20 c.c. HCl (1:1) and dilute to 100 c.c. Precipitate with H_2S, dissolve the precipitate in HCl with $KClO_3$. Filter off S, and add Fe_2Cl_6 solution of known strength until the color begins to show. Heat to 90° S. and add $SnCl_2$ until the color is discharged. All the Sb but none of the As is reduced before the Fe. Destroy excess of $SnCl_2$ by $HgCl_2$, dilute to 500 c.c. and titrate with permanganate.

Vermilion and Antimony Sulfide in India Rubber. Frank and Birkner (*Chem. Ztg.*, XXXIV., 49). Rapid and intense oxidation requiring but a short time of heating was the plan found most successful in the determination of such substances as these which are volatile on incinerating.

0.5 gm. of the powdered material in a small flask receives the addi-

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tion of 10 gms. of ammonium persulfate, and 10 c.c. of HNO_3 (gr. 1.5) is poured in. When the violent first reaction is over the flask is gently heated on a sand-bath until the vigorous escape of gases ceases—a result reached in less than 20 minutes. If any portions seem to remain unattacked add 2 or 3 gms. more of the persulfate in small portions. The mass should eventually become colorless and evolve no red fumes. Cool until there are signs of solidification, and then add 10 c.c. of HCl (gr. 1.124) and subsequently warm water. Filter from insoluble matters, and in the solution determine Hg and Sb.

Selenium—New Method. Ivanof (*J. Soc. Phys. Chim. Russ.*, XL., 661). An alkaline sulfocyanate together with a 25 per cent. solution of HCl on addition to a solution containing Se, afford selenocyanic acid, which when heated decomposes affording Se. The reaction is

$$2NH_4CNS + 2HCl + H_2SeO_3 = (HCNS)_2H_2SeO_3 + 2NH_4Cl.$$

The precipitated Se usually contains S, so the method serves best for purpose of separation. Te gives no corresponding reaction.

Selenium—Volumetric by Permanganate. Mirino (*Zts. anorg. Chem.*, LXV., 32). In acid solution, a brown coloration appears which obscures the end reaction. The titration is better managed by adding Na_2CO, until the solution is just alkaline, then running in the standard permanganate until a strong yellowish red color appears, then bring to a boil, and run in more permanganate until a decided permanganate color persists for 4 or 5 minutes. Then acidify with H_2SO_4 (1:3) and titrate back the excess by use of standard oxalic.

Nitrates if present should be removed by repeated evaporation to dryness with $ZnSO_4$ and H_2SO_4. The $ZnSO_4$ serves to prevent volatilization of the Se.

Tellurium. Browning and Flint (*Zts. anorg. Chem.*, LXIV., 104). Dissolve the material in 10 per cent. KOH, using about 1 c.c. for each 0.1 gm. TeO_3 supposed to be present. Make faintly acid with HCl, dilute to 200 c.c. with boiling water. Add dilute NH_4OH in slight excess, then acetic in quantity just sufficient to render it acid. On cooling the whole of the Te will have separated out, leaving Se in the solution. Filter and wash, dry at 105° or above, and weigh.

Gold in Cyanide Solutions. Whitby (*J. Chem. Met. and Min. Soc. S. Afr.*, X., 134). Add 15 or 20 c.c. of 15 per cent. $CuSO_4$ solution to 20 A.T. of the cyanide solution, shake well, acidify with 7 or 8 c.c. of H_2SO_4 (1:5), shake up again, and then add 20 to 30 c.c. of a 10 per cent. solution of crystallized $NaHSO_3$. Agitate well for 5 to 10 minutes, filter, and fuse the precipitate with 2A.T. borax and 1A.T. litharge, with enough argol or charcoal to afford a 25 gm. button. Cupel, etc.

Osmium. Ruff and Bornemann (*Zts. anorg. Chem.*, LXV., 429). Precipitation methods in which a reducing action is produced by alcohol, are all faulty in that some colloidal forms of Os escape in the filtrates. This disadvantage can be overcome by only neutralizing closely. The Os solution is heated in the water-bath, a solution of KOH containing alcohol added, and the excess then carefully neutralized by 2N acid, the addition being controlled by adding a little phenol-

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phthalein. All of the Os then separates as $OsO_2.2H_2O$ and can be readily filtered. This hydrate loses its H_2O with explosive violence between 100° and 150°, and should be heated up with great care in an atmosphere of CO_2 gas containing alcohol vapor.

Os oxides lower than OsO_4 can be converted to that form by heating with H_2SO_4 of 10 per cent. strength and CrO_3 in a bath kept at 120° C., oxygen being passed in. The OsO_4 volatilized is caught in KOH. This solution can be neutralized by H_2SO_4, KI added and the liberated I determined by titration with standard $Na_2S_2O_3$. OsO_2 is oxidized to OsO_4 by permanganate. In presence of HCl the end point is not sharp. If, however, excess of KOH is added, followed by excess of H_2SO_4 containing $MnSO_4$, a fairly accurate titration can be effected.

Bromide. Determining small amounts in presence of much chloride. Dibdin and Cooper (*Analyst,* XXXV., 159). Iodide may also be present in small amounts. The method depends on the fact that the solubility of Br and I in Cl water are diminished by the presence of a strong acid, that of Br especially so. For purposes of comparison use a solution of KBr containing 0.001 gm. Br per c.c. As reagents are required: H_2SO_4 50 per cent. by volume and saturated Cl water.

A convenient amount of the solution is taken in a Nessler tube, 10 c.c. of the H_2SO_4 added, and then the Cl water drop by drop until the maximum coloration is obtained. If a brown color due to I appears, add more Cl water. Match the coloration so obtained, by treating known amounts of the KBr solution in the same manner.

Free Iodine. Gooch and Perkins. When dissolved in KI, shaking with finely divided Ag, and determining the increase in weight of the Ag will serve to determine the I with accuracy, provided the operation is conducted in a flask from which the air has been excluded by introduction of H. The operation is complete when after frequent shaking the color due to the free I has disappeared. The Ag for the purpose may be obtained in various ways. The best form is that obtained by electrolysis on a small oscillating cathode of Pb.

Iodate in Potassium Iodide. Andrews (*J. Am. Chem. Soc.,* XXXI., 1035). Addition of starch and HCl may give a blue coloration due to traces of ferric or cuprous salts. If to the former, the use of acid potassium tartrate for acidifying will obviate the error. In the case of the Cu the same reagent will serve, but it must be applied in a solution from which the air has been boiled out, and the solution cooled out of contact with air.

Heat of Chemical Reaction as a Means of Testing. Howard (*J. S. C. I.,* XXIX., 3). In manufacturing fuming H_2SO_4 it is necessary to have a simple test which can be operated by the foreman. The author found this possible by noting the rise in temperature occurring on mixing 100 gms. of the sample with 100 gms. of H_2SO_4 of known strength in a Dewar tube. The temperature (a) of the sample is taken, also (b) that of the standard acid, and then (c) that of the mixture. The heat of reactions is then $c - (a + b)/2$. A table is prepared made up by observations on mixtures, the strength of which has been determined by analysis. For Nordhausen containing 20 to

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25 per cent. of free SO_3 an H_2SO_4 of 92 per cent. is used, the resultant mixture being nearly the monohydrate. The heat of the reaction ranges from 72° F. for 21 per cent. SO_3 to 102° F. for 26 per cent. SO_3; to all intents 6° increase for every 1 per cent. increase in free SO_3.

Per contra, by using a standard Nordhausen acid, the strength of the monohydrated acid may be determined. The suggestion is made that the principle may be utilized in other ways.

Sodium Sulfite in Presence of Sulfate and Thiosulfate. Weston (*Ch. News*, C., 176). Make a 5 per cent. solution of the sample, and add *N*/10 I solution drop by drop to 5 c.c. of this, until it becomes faintly colored. Decolorization may ensue from the presence of Na_2SO_3 or of $Na_2S_2O_3$ or both. But if at this point the solution reacts acid to litmus paper, Na_2SO_4 is present. To another 5 c.c. add half as much of the I solution as in the first case. The presence of SO_2 can then be recognized by its odor, and its reducing action on $K_2Cr_2O_7$.

Sulfur in Alkali Polysulfides. Dussene and Veillenmier (*Chem. Ztg.*, XXXIII., 1129). In preparations for use in viticulture, horticulture, etc., the amount of S present in polysulfide form is important. Dissolve 10 gms. of the sample in 500 c.c. of water; filter, and of the solution take 5 c.c. Place in a flask and add 30 to 40 c.c. strong NH_4OH diluted with an equal volume of water. Heat gradually to boiling, and run in *N*/10 $AgNO_3$ solution drop by drop. The liquid remains transparent up to a certain point, when a black precipitate suddenly forms, which subsides rapidly leaving a colorless supernatant solution. This phenomenon marks the end point, 1 c.c. of the $AgNO_3$ solution = 0.0016 gm. S as polysulfide.

Phosphorus Oxides When Mixed. Rosenheim and Pinsker (*Zts. anorg. Chem.*, XXIV., 327). A method is based on these facts: (1) By oxidizing with HNO_3, total P can be determined as $Mg_2P_2O_7$. (2) H_3PO_2, H_3PO_3 and H_3PO_3 may be titrated by use of permanganate. (3) I will oxidize only H_3PO_2 and H_3PO_3. (4) $UO(NO_3)_2$ precipitates only H_3PO_4 and H_2PO_3.

Phosphates and Vanadates. Jannash and Jilke (*J. Pr. Chem.*, LXXX., 113). When in combination with Fe, Cr, U, Co, Ni, Mn or Zn, not with Al, the P of phosphates can be entirely volatilized by heating in an atmosphere of CCl_4. About 0.3 gm. of the material is mixed with powdered quartz, and placed in a SiO_2 boat in a combustion tube, to which is connected a tube terminating close to the surface of water in a flask. The vapors escaping from this flask escape through water in bulb tubes. A plug of glass wool is placed in the tube near the delivery end, to hold back metallic chlorides. Dry CO_2 is first passed through to thoroughly dry the material before passing the CCl_4 vapor, and is passed afterwards to sweep out the last traces of what is supposed to be phosphoryl chloride. One hour at dull red heat will suffice to decompose $FePO_4$, but the other phosphates require a bright red heat, and 2½ hours treatment.

The same treatment was found to be successful in separating V from its combinations (*ib.*, p. 127). In that case, however, dilute HNO_3 should be used in the receiver.

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With Na phosphates and vanadates, the material has to be mixed with four times its weight of NaCl to insure its decomposition.

After the treatment, the solutions in the receiver and bulb tubes will contain the P or V (or both), and can be handled by the usual methods.

Phosphorus in Bronze and Similar Alloys. Schürmann (*Mitth. Kgl. Material. Prüf.*, XXVII., 474). The solution of the alloy — 2 gms. in 100 c.c., receives the addition of 20 c.c. conc. HCl, and when cooled about 1.5 gms. of a ZnMg alloy are added in small portions at a time with frequent agitation. Then after standing 15 minutes on the water-bath, it is filtered, 20 c.c. SO_2 solution added, and it is boiled. Any As remaining is precipitated with H_2S, and the solution, after proper treatment, is precipitated with molybdate, etc.

Commercial Silicon. Weiss and Engelhardt (*Zts. anorg. Chem.*, LXV., 38). The best method of bringing the material into solution for analysis was found to be fusion of 0.5 of the substance with 10 gms. $NaKCO_3$ and 0.5 gm. KNO_3. About half of this mixture is used to line a platinum crucible, then a mixture of the flux and substance is introduced, and the whole covered with the remainder of the flux. Heat moderately until gas is no longer evolved, then apply the blast until it fuses clear.

Ultramarine. Andrews (*Analyst*, XXXV., 157). The addition of HCl to a sample of ultramarine causes more or less separation of S and gelatinous silica, so that the presence of foreign additions are to some extent masked. The use of Br water obviates this. The method recommended is to wet down 1 gm. of the sample with 5 to 10 c.c. of water. Diffuse it through the water by shaking, then add about 30 c.c. of saturated Br water, and shake, continuing this treatment until a fair excess of Br shows in the solution. Allow to stand about 15 minutes, and then filter rapidly. Wash, dry, ignite and weigh the insoluble residue. Boil with Na_2CO_3, filter, wash, etc., and weigh again to recover a small amount of separated SiO_2. The analyses recorded show 2.4 to 4.4 per cent. insoluble clay—a manufacturing impurity. The filtrate is evaporated down with HCl to obtain SiO_2 and the solution therefrom is divided in halves, in one of which S is precipitated as $BaSO_4$, in the other, Al_2O_3 is determined.

Coal, etc., Mixed with Clay. Lissner (*Chem. Ztg.*, XXXIV., 37). In making an elementary analysis of coal containing clay, some of the water held by the clay may not be driven out until the combustion is made, when it causes an incorrect estimation of the organic H of the sample. Springer has suggested evaporating with HF and drying before combustion. The author finds it best to evaporate two or three times with a mixture of 2 parts HF and 1 part conc. HCl. The material is then filtered on an unweighed filter, and when washed and dried a portion is taken out, and submitted to combustion to determine the ratio between C and H. In another sample of the coal the C is determined and from the ratio found, the percentage of organic H is calculated.

Coke—Ash and Phosphorus. Ullmann and Buch (*Chem. Eng.*, X.). 5 gms of the coke, ground to pass 100-mesh, is weighed out in a round-

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bottomed platinum dish of about 150 c.c. capacity. It is then wet down with about 5 c.c. of alcohol, and by a little careful tipping and turning of the dish, the material is spread fairly evenly over the bottom and sides. When this has been accomplished the alcohol is set on fire, and as soon as it has burned off the full flame of the blast lamp is applied in a way to heat the sides as well as the bottom. Reduction to ash is quickly accomplished (20 minutes).

After weighing up ash, tap the disk gently to shake the most of the material to the bottom, pour on 10 c.c. conc. HNO_3, then 10 c.c. water and then 3 to 5 c.c. HF, cover and boil down to 5 or 10 c.c., add 30 c.c. of hot water—boil a few minutes and filter. In the filtrate P may be determined by the ordinary methods.

Asphalt and Paving Mixtures. Prettner (*Chem. Ztg.*, XXXIII., 917 and 926). The $CaSO_4$ obtained from the ash may be partially or entirely obtained by oxidation of the organically combined sulfur, which subsequently reacts upon the $CaCO_3$ present. To avoid such error, it is recommended to prepare a mixture of conc. HCl saturated with ether cold (about 2 of HCl to 3 of ether). To 2 gms. of the dried sample in a 150 c.c. flask are added 15 c.c. of this mixture.

Mix by aid of a flattened glass rod and add in 3 or more successive portions. After thorough mixing add 5 c.c. more, and then 10 to 15 c.c. water. Then add 40 to 50 c.c. of hot water, and immerse in hot water to expel the ether. Cool and filter, washing the bitumen adhering to the sides of the flask with dilute HCl. In the aqueous filtrate, the SO_3 is determined by $BaCl_2$. Another portion after fusing cautiously with Na_2O_2 will serve to determine total S, and hence, by calculation, the organic sulfur. The bitumen adhering to the flask may be extracted with $CHCl_3$, the solution filtered into a weighed dish, and by evaporating off the solvent, drying, weighing, incinerating and weighing again, the amount taken up by the solvent may be determined. The ash should always be treated with a little H_2SO_4, ignited and weighed a second time to determine the amount of CO_2 present by calculation on the difference between $CaCO_3$ and $CaSO_4$.

Asphaltic Material. Bornemann (*Chem. Ztg.*, XXXIII., 1225). To effect subdivision moisten with alcohol, and grind to a smooth paste in an agate mortar. Evaporate off the alcohol by standing in a warm place, and finally dry at 105° to 110° C.

For *Bitumen.* Moisten 2 gms. of the pulverized material with 2 c.c. of alcohol, and stir in 10 c.c. conc. HCl. After 10 to 15 minutes, add 50 c.c. of water, and decant through a 9-cm. filter on which about 1 gm. of finely shredded asbestos has been collected. Transfer the bituminous residue to the filter and wash by use of about 100 c.c. of hot water. Dry filter, beaker and rod at 105°–110° and extract all with 75 c.c. of a mixture of 10 parts chloroform with 2 of alcohol, Pass the filtrate through the paper a second time, and then transfer to a Soxhlet and extract with the same solvent until it runs off colorless.

Gypsum will be found mainly in the HCl extract made as above, but some will also be found in the residue after extracting the bitumen, and must be dissolved out by HCl, and the solutions united.

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Silica. Incinerate a portion strongly, add HCl and evaporate to dryness in the usual manner for SiO_2 determination.

For closer examination of the bituminous material Parr, Mears and Weathershed describe a method on the plan suggested by Leverette—partial precipitation by modification of the solvent. About 0.5 gm. of the material is dissolved in 5 c.c. of CS_2. Then 100 c.c. of hexane (sp. gr. 0.6516) is added, and, after standing 2 hours, the mixture filtered through a Gooch crucible, dried at 105° and weighed = "Precipitate I." The filtrate from this was evaporated to dryness, taken up with 10 c.c. hexane, and the solution added gradually to 300 c.c. methyl alcohol. The precipitate = "Precipitate II.," was filtered off, dried and weighed as before. The filtrate was evaporated to dryness, and the residue, "Precipitate III.," dried and weighed. Precipitate I. (except in the case of coal tar pitch) was friable at 105° and manifested the characters of what has been termed "asphaltene." Precipitate III. resembled a viscous machine oil. Precipitate II. appeared intermediate.

Commercial Cyanide. Seamon (*Chem. Eng.* X., —). Dissolve 20 gms. in 150 c.c. of water, filter into a 250-c.c. flask, wash, ignite and weigh the insoluble residue. Add $Ca(NO_3)_2$ to the contents of the flask, shake well, dilute to the mark, mix, let stand an hour, filter off $CaCO_3$ and wash. The amount can be determined by strong ignition and weighing CaO.

The filtrate and washings are brought to 500 c.c., of which 100 c.c. is taken for hydroxide determination. Add $Mg(NO_3)_2$ solution, let settle for an hour, filter off, etc., ignite and weigh MgO. The weight $\times$ 0.85 gives that of hydroxide in 4 gms. of the sample.

For cyanide take 50 c.c. of 500 c.c. dilution, add 5 c.c. strong ammonia and 5 c.c. of the KI indicator. Then titrate with standard $AgNO_3$. Cl factor $\times$ 0.7324 = CN factor.

For cyanate. To 50 c.c. of the above add excess of strong $AgNO_3$ to precipitate all Cu, CNO and Cl. Shake well, filter and wash with ice-cold water. When washed, place a clean flask under the filter, and pour over the filter 10 c.c. of standard HNO_3 made up by mixing 100 c.c. HNO_3 with 900 c.c. of water. Titrate acidity with standard NaOH. Each mol. of HNO_3 neutralized corresponds to 1 mol. CNO.

For Cl. Heat up 1 gm. of the sample in a porcelain crucible and add gradually a mixture of 5 parts Na_2CO_3 to 1 part KNO_3 until all CN is destroyed. Cool, dissolve, acidify with HNO_3, filter, and determine Cl in the solution by titration.

For K and Na. Decompose 0.25 gm. by heating with HCl, finally evaporate to dryness and weigh NaCl + KCl. Determine K by $PtCl_4$.

Commercial cyanide containing more or less NaCN is usually preferred, the lower combining weight of Na giving the greater proportion of CN.

Calcium Acetate. Jedlicka (*Zts. anal. Chem.*, XLIX., 97). By a uniform method of treatment the distillation method can be shortened, *e. g.*, the author treats 5 gms. of the sample in a 300-c.c. Erlenmeyer

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flask with 50 c.c. of water and 50 c.c. of H_3PO_4 (sp. gr. 1.20), distilling until spirting begins. Then 50 c.c. of water are added, and the distillation continued to the same point. The combined distillates are then titrated, and 0.1 c.c. *N* NaOH added to the c.c. used to compensate for the additional acid obtainable by subsequent distillations. The first distillation should last an hour (87 to 90 c.c.), the second half an hour.

Hydrogen in Gas Analyses. Paal and Hartmann (*Ber.*, XLIII., 243). That colloidal solutions of Pd will absorb H has been shown before. The solutions are expensive, and require constantly to be regenerated by treatment with O. By mixture with picric acid the Pd acts as a catalyst, and regenerates its absorptive power so long as the picric acid remains. A solution containing per 100 c.c. 2 gms. picric acid and 2 gms. of colloidal Pd is recommended for an ordinary Hempel pipette. Naturally its activity is promoted by shaking, and it acts more slowly as the picric acid becomes exhausted. In analytical work, CO_2, unsaturated hydrocarbons, O and CO must first be removed, before applying the reagent.

Water in Petroleum. Roberts and Fraser (*J. S. C. I.*, XXIX., 197). The method consists of an adaptation of the process of Dupré (vide QUARTERLY, XXVIII., 237)—admixture with CaC_2 and measuring the gas evolved. To meet the necessary conditions the apparatus is essentially different. The petroleum tested is weighed out (17.26 gms.) in a small flask. This flask is connected with a large (closed) bottle containing saturated NaCl solution. A tube from this bottle carries over into a graduated cylinder the water displaced by the gas evolved. When CaC_2 is dropped into the weighed portion of the sample, and the flask closed, the volume of the evolved gas is measured by the amount of NaCl solution forced into the graduate.

Reduced to standard temperature and pressure, every 100 c.c. corresponds to 1 per cent. H_2O in the sample.

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BOOK REVIEWS.

The Cost of Mining. An Exhibit of the Results of Important Mines throughout the World. By JAMES RALPH FINLAY, Secretary Mining and Metallurgical Society of America; Lecturer at Harvard University on the Economics of Mining. New York, 1909, McGraw-Hill Book Co. 415 pp., 22 illustrations. Price, $5.00.

This book contains 21 chapters, entitled: Value of Mining Property; Factors Governing Variations; Partial and Complete Costs; Statistics of Coal Production; Cost of Mining Coal; Cost of Mining Lake Superior Iron; Occurrence and Production of Copper; Lake Superior Amygdaloid Copper Mines; Conglomerate Copper Mines of Lake Superior; Copper Mines or Fissure Veins in Montana, Australia and Arizona; Various Copper Mines of Arizona and Mexico; Copper Mines of Various other Districts; The Copper Mining Business in General; Lead; Silver-Lead Mining; The Cost of Silver-Lead Smelting; Zinc Mining; Occurrence and Production of Gold; Quartz-Pyrite Gold Mines; Cripple Creek, Kalgoorlie and Goldfield; Silver Mining at Cobalt and Guanajuato.

Readers of the *Engineering and Mining Journal* will remember that Mr. Finlay contributed to that periodical in 1908 a series of papers on the "Cost of Mining." In these articles the costs at a number of well-known mining properties were discussed and analyzed at some length. The present book is an extension of Mr. Finlay's previous writings, but comprises also material resulting from correspondence and discussion occasioned by the articles mentioned, together with some matter contained in lectures given by the author at Harvard University.

The writer of this work is well fitted by his professional experience to treat of this important subject, and to his other qualifications he has added industry in collecting cost data and discernment in comparing them. During the past few years—since about 1905—the subject here dealt with has attracted more and more attention in technical journals and transactions, and the discussions in which many engineers and mine managers have taken part have clearly shown the need which has long existed in many branches of the mining industry for a more rational, standardized method of cost-keeping. In this connection the first three chapters of Mr. Finlay's book, especially Chapter III., on "Partial and Complete Costs," will be found valuable to both managers and investors. It is unfortunate that a considerable number of the larger mining companies omit or refuse to publish financial statements or cost sheets that are at all enlightening. Such publicity could be productive of nothing but benefit to the stockholders and it is hard to understand how it could injure any honest, efficient management. It is to be hoped that Mr. Finlay's treatment of the subjects of charges for operating, maintenance, depreciation and amortization, and

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his criticism of incorrect or dishonest use of these cost items, will be productive of good to all concerned.

Besides the matter relating to right and wrong methods of cost-keeping, the numerous examples of actual costs, taken from representative American and foreign mines, of many different kinds, will be found valuable by all interested in the mining industry.

R. P.

History of the Clay-working Industry in the United States. By HEINRICH RIES and HENRY LEIGHTON. 8vo, pp. viii + 270. $2.50. New York, John Wiley and Sons.

In the series of monographs dealing with the history of various industries in this country, and issued by the Carnegie Institution, this work has an honorable place. Few people realize that an everyday business like the making of brick and pottery ranks among the most important of the national manufactures. The use of clay began of course long before the whites crossed the Atlantic, since its employment for simple pottery seems to be the universal heritage of primitive peoples. For brick, clay was utilized by the colonists very early in the sixteen hundreds in both Virginia and New York. Still, we are interested to note that cargoes of brick were imported at the outset for the houses of the settlers, and only later did this homely industry strike root.

Professor Ries is the author of a long series of reports upon clay for various states and for Canada. The wide acquaintance with North American resources thus gained has proved of great service, and with the help of Mr. Leighton a very serviceable book has been prepared. The states and territories of the union are passed in review and under each the industries using clay are traced from their inception to the present. The work makes interesting reading for the student of economics but it will be specially valuable to those actively engaged in the production of brick, pottery, porcelain and in related manufactures.

J. F. K.

Modern Assaying. By J. REGINALD SMITH, edited by F. W. BRAUN. Philadelphia, J. B. Lippincott & Co., 1910. Pp. 145; 80 illustrations.

Apparently this book was supposed to be an elementary treatise of assaying which would enable the novice to master the subject without great difficulty; but in reality, with few exceptions, it is one of the poorest collections of rough methods that has appeared in some time.

The book is poorly written. The descriptions are frequently deficient and could not be followed without much technical information not contained. Methods are given which, aiming at rapidity, are longer and less accurate than those in general use. The majority of charges for fire work are absolutely useless if satisfactory results are to be obtained.

The book is well illustrated particularly with equipment manufactured by F. W. Braun.

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It would be interesting to know where the information for compiling this book was obtained and why it was written unless for advertising purposes.

E. J. Hall.

Lo Zinco. Roberto Musu-Boy. Milan, Ulrico Hoepli. 230 p., ill.

The Metallurgy of Zinc is dealt with in thirty chapters. Historical; Properties; Ores; Analysis; Geology; Metallurgy; Calcination; Concentration; Methods of Reduction; Electrolytic Process, etc.; Alloys; Zinc Deposits, Italian and Foreign; Uses; Manufacture of Zinc White.

Aside from the section on Italian deposits the book calls for no comment. Under the heading of Methods of Reduction there are no illustrations of retort furnaces, while the section on Zinc Alloys is long out of date.

W. C.

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CHARLES FREDERICK CHANDLER

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THE

SCHOOL OF MINES QUARTERLY.

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CHARLES FREDERICK CHANDLER.

The approaching retirement of Professor Charles Frederick Chandler makes every graduate of the School of Mines and of Columbia College for over forty years past grow reminiscent in his mind, misty in his eyes and very tender in his feelings. Members of the Society of the Older Graduates recall the time when Professors Egleston, Chandler, Van Amringe, Newberry, Joy, Peck, Rood and Vinton were working like beavers to build up engineering education at Columbia, Members of the Early Eighties knew all these except General Vinton. In his place had come the dearly loved Professor Trowbridge. To students of the last ten years, Egleston, Newberry, Rood and Trowbridge are but names. "Van Am" and Dr. Chandler are still with us, and if we could have our way, they would be with us to the end of time. They two remind the later generation that as regards early years in the School of Mines, "There were giants on the earth in those days."

Charles Frederick Chandler first opened his lungs to the elements and other things composing the atmosphere in the town of Lancaster, Mass., December 6, 1836. If he took in with his first breath all the varied assortment which his subsequent lectures have led us to believe, his first cry must have been not only lusty but indignant. Up to the time of his birth, the town of Lancaster had been chiefly famous for its andalusite crystals; but thereafter it became no less widely known for its Chandler.

The future professor of chemistry passed his youth as did other boys of his day, but as he grew to manhood he resolved to follow

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the branch of science which has since become his life-work. As he told us at the dinner arranged in his honor, on April 2, Harvard was at that time one of the leading universities of the country, and to the Lawrence Scientific School he repaired and began the study of chemistry and allied branches. The laboratories of those days were simple and equipment severely plain. Bunsen burners had not yet been invented. Quantitative analysis was in its infancy. Natural science of all sorts maintained a somewhat precarious existence in American colleges against the religious prejudices of the day. Chandler, the student, after a stay of a year set out for Germany and matriculated in the University of Goettingen, then the favorite university with American students. Later he moved to Berlin. Wöhler, the great teacher of chemistry of the day, was in the full tide of his activities. To him resorted a great proportion of the students in this branch and his wonderful versatility sufficed to keep them well advised and busily employed, no matter whether they pursued organic or inorganic chemistry, metallurgy or other branches of chemical science. Like many another young chemist, C. F. Chandler, *studiosus rerum naturæ,* caught the inspiration and labored long but happy hours at his laboratory desk. In 1856, at the age of nineteen he made his doctorate, and his "Arbeit" was entitled, "Miscellaneous Chemical Researches." Among the subjects investigated in its preparation we observe a series of minerals involving unusual and difficult chemical analyses, such as columbite, tantalite, yttrotantalite, samarskite, zircon and stassfurthite. All of his results may be found duly recorded in Dana's "System of Mineralogy," and referred to "C. F. Chandler, Inaugural Dissertation 1856." We are forced to conclude that Heinrich Rose the German professor under whom this young candidate for the doctorate worked, must have handed over to him a choice assortment of minerals, the difficulty of whose analysis had led to their gradual accumulation on the side.

Some years before 1856 there had returned from Germany another American student of chemistry in the person of Charles A. Joy. Dr. Joy had found a place to teach at Union College, Schenectady, then as now a favorite institution of learning especially for the young men of the Upper Hudson Valley and eastern central New York. In 1857 Dr. Joy was called to the chair of chem-

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istry in Columbia College, and Dr. Charles F. Chandler, twenty years of age, succeeded him at Union. For seven years Dr. Chandler taught the Union College students and entered into the life of the institution.

In 1863, as every old Mines man has heard from Dr. Chandler's own lips, the project of a School of Mines was broached to the trustees of Columbia College by Thomas Egleston, a Yale graduate, who had recently returned from a course of study in the École des Mines of Paris. The proposal was made just a year before the time at which Dr. F. A. P. Barnard became president of the college, and it later found in him a man strongly sympathetic with scientific and technical education. There was indeed great need of attention to this branch in America. Mining was in its infancy, despite the fifteen years which had elapsed since the discovery of gold in California. Ten years before, J. D. Whitney, the great missionary to the Americans in the preaching of sound and reasonable views on ore-deposits and mines, had published his "Metallic Wealth of the United States." It had done much to prepare the way for the favorable consideration of education in this branch of work. The many wild-cat schemes and "get-rich-quick" allurements of the day made the new departure still more desirable. Despite the upheaval of the Civil War, and the industrial disturbances that followed in its melancholy train, the trustees of the college gave favorable heed and in 1864 authorized the inauguration of the new school. Nevertheless in perhaps a properly conservative spirit toward an experiment, they did not attach salaries at the outset to the professors' chairs. Thomas Egleston became the first professor and had charge of mineralogy and metallurgy. Francis L. Vinton, a graduate of West Point, was the second appointee as professor of mining engineering. Help was especially need in chemistry and Professor Joy suggested the man who had been his vigorous successor at Union. In consequence Charles F. Chandler became professor of analytical and applied Chemistry. From the faculty of Columbia College Professors Van Amringe, Peck, Rood and Joy volunteered their services, and the next year, 1865, were regularly appointed as professors. In 1866 Dr. John S. Newberry was called to the chair of geology, and as thus constituted the faculty of the School of Mines, except for junior officers, remained unchanged for ten years.

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In this way Dr. Chandler, delightfully free from the responsibilities of having a salary to burden him with its expenditure, moved to New York and began his career at Columbia. He was then twenty-seven years of age, a teacher of seven year's experience, and thoroughly oriented to conditions in his native land after his European training. Dr. Chandler taught both chemistry and geology in his first two years at the School of Mines, and was the first dean of the infant faculty.

We of to-day live in an era of larger things, of vastly better equipment and of wider horizon, but we may, none the less, somewhat enviously think of the early days when small classes sat informally around tables, with keen and ambitious instructors and in close personal association.

The School of Mines grew rapidly. It enlarged its courses and became an institution for instruction in practically all branches of engineering. Mathematics, physics and chemistry are fundamental to them all, so that Dr. Chandler's department has been basal in all the subsequent development.

In 1872 Dr. Chandler became adjunct professor of chemistry in the College of Physicians and Surgeons, and in 1877 was appointed to the full chair. In this year he also entered the faculty of Columbia College, on the retirement of Professor Joy. Chemistry, thus, in all schools of the university, became unified and Dr. Chandler's title was that of professor of chemistry.

In 1866 Dr. Chandler began to lecture on chemistry in the College of Pharmacy, which had been founded in 1829 and which since 1904 has been an integral part of Columbia. With a single interruption, Dr. Chandler has given the chemical lectures for forty-four years.

Let us now imagine the daily round of this tireless worker in the decades of the seventies and eighties. Lectures and Dean's duties in the School of Mines; lectures in the Medical School; lectures in the College of Pharmacy; duties of the Board of Health; incidental expert work; and the calls which naturally come to one of the leading citizens of the community. We wonder at the iron constitution that stood up in strong health under the demands. Looking back from the vantage point of to-day, the old School of Mines students who used to interview Dr. Chandler, need not be

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surprised that they often had to waylay him on the street or in the "Pass of Thermopylæ" at the old site, and trot along beside his big familiar market-basket of documents while they set forth their cases. The basket of papers often represented the results of midnight or early morning hours of work.

Beside his work in the schools of the university, outside activity also claimed his attention. He became chemist to the City's Board of Health in 1867, and a few years later its president. The latter office he held until 1884. After a hard fight the board obtained and exercised autocratic power over the food supply, and made its influence felt in preventing the dilution of milk, the sale of unwholesome fruit and in many other lines. Improved sanitation, control of contagious diseases and many additional reforms vital to the well-being of the community became firmly established and have remained ever since normal features of municipal administration. Not a few young graduates in the course in chemistry gained their first experience in professional life, by boarding incoming milk trains in the early morning hours, and testing the cans of the white fluid with lactometers.

Dr. Chandler began the publication of the *American Chemist* in 1870, and in association with his brother William, continued its issue until 1877. It was a pioneer journal and exerted a strong influence in the American development of the science.

When the National Academy of Sciences was created after the close of the Civil War as a body of our most distinguished scientific men, whose advice, if needed, would be at the service of Congress, Dr. Chandler was one of the early appointees. He later entered into the organization of the American Chemical Society and was its president from 1881–89. He was largely instrumental in the formation of the New York Chemists Club and was its President 1894–95. A vigorous society, soon to possess a fine club house is the result. His crowning honor came in 1899 when he was chosen president of the Society of Chemical Industry. He delivered the annual presidential address at the meeting in London. Dr. Chandler chose for his subject, a sketch of the development of technical education in the United States, a paper which is of decided historical value and interest. While in England, at this time, he received the honorary degree of doctor of science from the University of Oxford.

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These and many other honors have befallen Dr. Chandler and they are duly set forth in the current biographies. His old students and his colleagues are proud that he has received them and with one accord they rejoice at the awards. But what we all like best to remember is the kindly and merry disposition that has been so grateful and welcome to more than two generations of students who have crowded the benches of the chemical lecture room. The hour was never dull. The lecturer seemed always in his happiest mood. The exposition of chemical principles and reactions was constantly illumined by a jest or a bit of significant experience gained from long years of familiarity with the applications of chemistry to the problems of life. Class after class has hung upon his words and man after man has carried into his future career a fund of every-day knowledge which has been invaluable.

But this is not all—outside the lecture room, the students have ever found in Dr. Chandler a friend to whom, despite his thousand cares and pressing engagements, they could freely go. Generous both of himself and of his means to them and to the department, he has been, lo, these many years, a pillar of strength in the educational structure which is Columbia University.

J. F. KEMP.

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JOHN HOWARD VAN AMRINGE

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JOHN HOWARD VAN AMRINGE.

A sketch of the life of John Howard Van Amringe becomes almost a history of Columbia College and of the School of Mines for half a century, not only because he has for so long been intimately connected with these institutions, but because round him have grown the affections of generation after generation of Columbia students.

Better known to Columbia men as "Van Am" he has been for years a most active and popular figure in the life of Columbia.

He was born in Philadelphia on April 3, 1835.

An ancestor, Lionel Van Amringe, was an officer under Frederick the Great, and it is supposed that from this source came the "martial air" for which the Dean is famous.

His family came to Pennsylvania in 1791 and from there to New York in 1841. After a few years of study under his father and further training at the Montgomery Academy, Orange County, N. Y., he was sent to Yale in 1854. At the end of his second year he left college and for two years engaged in tutoring.

He entered Columbia College in 1858 as a junior and graduated in 1860. The same year he became tutor in mathematics and in 1863 was promoted to the rank of assistant professor.

In 1864 he was appointed lecturer in the School of Mines, which was just then being established and in 1865 he was appointed professor of mathematics. Ever since then he has been head of the department of mathematics and until lately he has conducted his classes in person.

Since 1894 he has been dean of the college.

In 1899 he was made acting president in the temporary absence of President Low.

He has been the recipient of many honorary degrees; in 1897 New York University gave him a Ph.D., in 1880 Columbia presented him with the degree of L.H.D. In 1895 Union College conferred on him the degree of LL.D., and this year Columbia has done likewise.

Professor Van Amringe has given up much time to the activities of the church to which he belongs, serving as a vestryman of

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Trinity Church and as a trustee of several societies of a religious character.

He has also been interested in politics. Some of us remember his connection with the City Reform Club in its early days, when we listened with the greatest interest to his attacks on the corruption in New York City politics.

For fifty years Professor Van Amringe has served the university with unwearied diligence and zeal and with great success as a teacher.

His double connection, as instructor and as dean with the many hundreds of students that have sat in his class-rooms and sought his counsel, and submitted to his discipline, has given him a position unique in the collegiate world.

But it is not only on his merits as a mathematician or an instructor that his reputation rests, although he was a teacher of singular clearness and force.

As the trustees expressed it in the minute adopted by the board: "His unique distinction, and the affectionate regard of all his pupils and colleagues have been won in the field of college administration as well as in that of teaching. His unexampled success in that field has been due in part to his long experience, in part to his clear grasp of the special problems of this college, in part to his strong sense of justice and fair play; but above all to that love for and sympathy with and understanding of the undergraduates under his charge, which have been the most distinctive and attractive feature of his striking personality."

While he was always stern and often severe, it was conceded even by those students who experienced his displeasure, that he was fair and just in his treatment of those who had perforce to come before him.

A lover of athletic sports, he was ever on hand especially at the rowing contests to inspire our athletes by his presence. It is needless to say that the knowledge that he was so much interested in their success was a great encouragement to them.

It had however, another effect, in that it gave to the alumni of the university a focusing point for their enthusiasm, no gathering of alumni being complete without him, and in recent years an opportunity to sing "Do you ken Van Am?"

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As he was the strongest tie binding the old Columbia of 49th Street to the new Columbia of Morningside, the students of the old Columbia will feel most keenly the change produced by his retirement.

Much more might be said of the work he has done for Columbia even as far back as the "early sixties" when as secretary of the Alumni Association he was trying to put some of his enthusiasm into what was then almost a lifeless body; and again in these later days when he did so much in developing the Columbia University Club of which he is and has been from the beginning the honored president.

The measure of Dean Van Amringe's work for Columbia is not only what he has himself done, but what he has inspired others to do.

It is hoped that for many years to come he may continue to serve Columbia in this way even though his active official connection with his Alma Mater has ceased.

WILLIAM FELLOWES MORGAN.

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A FULGURITE FROM THE RARITAN SANDS OF NEW JERSEY WITH AN HISTORICAL SKETCH AND BIBLIOGRAPHY OF FULGURITES IN GENERAL.*

By WALTER L. BARROWS.

The fulgurite which is the occasion of this paper was found by Mr. Frank M. Crossman at the Crossman clay and sand works at South Amboy, N. J., in March, 1909, and was presented by him to Mr. H. McC. Bangs, at that time a student in Columbia University, who turned it over to the department of geology through Mr. Edmund Kirk.

According to the accounts of Mr. Crossman, the fulgurite was discovered in a thick bed of quartz sand known in the New Jersey Geological Survey reports as the No. 3 sand of the Raritan formation.† The accompanying sketch shows the field relations. The sand is underlain by the South Amboy fire-clay, whose thickness in the Crossman works is very variable and within a few hundred feet increases from two to twenty feet. Normally it is a tough, light blue-gray clay, containing scattered bunches of pyrite crystals running up to two and three inches in diameter. Its upper portion is in places full of carbonaceous and lignitic material.

The No. 3 sand in which the fulgurite occurred is composed in great part of angular grains of quartz of variable size, with a small percentage of dark silicates and practically no feldspar, and is unfossiliferous. In places the clean sand rests directly upon the underlying clay; elsewhere there is as much as 15 ft. of sand, black with carbonaceous material, and sandy clay, intervening between them. At the place where the fulgurite was found there is only a foot or so of this dark material.

* Submitted in partial fulfillment of the requirements for the degree of Master of Arts under the Faculty of Pure Science of Columbia University, 1910.

† See p. 166. N. J. G. S. Report for 1904 on "Clays and Clay Industry."

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The sand bed at the Crossman works is from 50 to 60 ft. thick, and of very uniform character from top to bottom. There occur in it throughout many limonitic streaks which run at low angles with the horizontal and with each other and from a distance give

FIG. 1. Map taken from the New Brunswick quadrangle. The cross indicates the location of the pit where the fulgurite was found. Scale .66 in. to the mile.

a cross-bedded effect. These streaks are due to the oxidation and hydration by percolating waters of thin beds in the sand rich in iron-bearing minerals. When examined closely they show at their upper surface a thin layer of metallic limonite, while the rest of their breadth is composed of quartz grains loosely cemented together by the same mineral. There are also in the sand occasional thin clay layers. Both the sand and the underlying fire-clay are being dug through their full thickness for commercial purposes.

The sand is overlain by from 8 to 10 ft. of the Pensauken formation* here consisting of yellow-brown cross-bedded gravels at the base, overlain by coarse sand of the same color. This formation is considered by the New Jersey Survey to be an out-wash

* See N. J. G. S. Report for 1897, p. 15.

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deposit of one of the earlier glacial epochs, perhaps the Kansan or Albertan.

I have described the field relations of the sand in which the fulgurite was found with some fullness because they are of importance in considering its time of origin. According to Mr. Crossman's best recollection the tube was found in the No. 3 sand

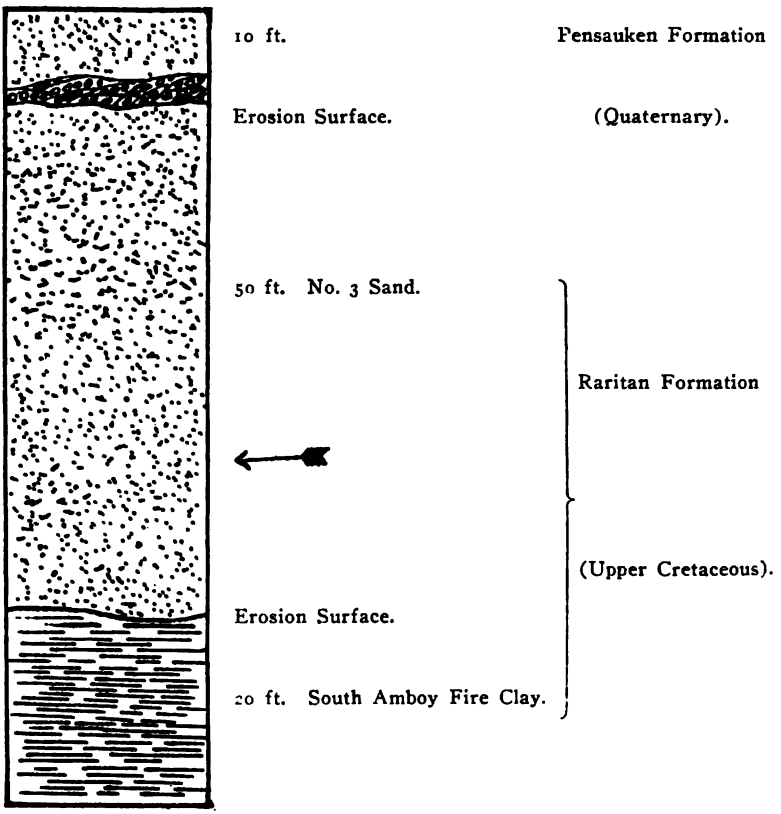

FIG. 2. Geological Section at the Crossman Works. The arrow indicates the position of the fulgurite.

at a point from 15 to 20 ft. above the clay, and therefore at from 45 to 55 ft. from the surface, and ran at a low angle to the horizontal for about 15 ft. parallel to the face of the bank.

It is unfortunate that the facts concerning the occurrence of the fulgurite could not have been recorded accurately at the time it was found. Mr. Crossman's testimony is, however, corroborated

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to a certain extent by the fulgurite itself. As received by the university, it consisted of about 100 pieces which placed end to end would measure roughly 19 ft. Making allowance of 50 per cent. for duplication by branching would reduce this to 10 ft., but as it is impossible to tell how great this duplication was, the length may have very well been 15 ft. The fact that the tube could not have followed a vertical course is attested to by the fact that it crosses very few of the limonitic layers. The crossing of these layers is always shown by the bulging of the tube into an irregular red and black knot containing many openings, and there are only three of these knots shown in the specimens. If its course had been vertical it could hardly have escaped passing through at least a dozen of these layers. Of the three shown, two are only about an inch apart, and the tube seems to cross them vertically. The other one it crosses at an angle of about 40°. Since the limonitic layers may make an angle of as high as 30° with the horizontal the angle of the path of the fulgurite with the horizontal may have been as low as 10°.

In appearance the fulgurite exactly resembles many that have been heretofore described. There are almost 100 pieces, whose exterior diameter varies from 3.2 cm. to .3 cm. An attempt was made to fit the pieces together, but this proved impossible owing to the fact that many of the ends were broken. The following variations could be made out, starting at the upper end of the tube. First, a series of pieces in which the diameter of the lumen is large as compared with the thickness of the walls. In these the cross-section is roughly circular; the exterior is irregular, but the interior walls follow all the deviations of the outer; in other words, the thickness of the walls does not vary much. This series grades imperceptibly into another in which there is an increase in the thickness of the walls and in the irregularity of their outline. Here the cross-section of the lumen is extremely irregular in shape and the thickness of the wall varies within wide limits.

The longitudinal furrows and ridges are not prominent in this portion. These ridges are seldom continuous over more than 3 to 4 cm.; they are broken by gaps, sometimes two of them join; others show a tendency to twist spirally around the tube. In this section the tube divides into two branches of about equal size.

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This series grades into another which represents the final products of the decreased electric energy. The fragments in this series are characterized by decreased diameter, walls which may be as thick as the diameter of the lumen, and more nearly circular outline. The course of this end of the tube is sometimes very irregular and there are small pieces which follow a distinct spiral, others which almost double on themselves, and one which is deflected almost at right angles five times in succession within a few inches.

Throughout the length of the tube the outside is rough with adhering sand grains, mostly quartz, some clear and seemingly unaltered, the majority, however, rendered opaque, and giving to the fulgurite its characteristic external color. Patches of red, brown, and black are frequent, due to the presence of oxidized iron. The swollen knots at the crossing of iron layers in the sand are of these colors, of which a brownish-red is the most characteristic. The number of openings through these knots and their large diameter show that the iron caused the fused mass to become much more fluid. Across one of these openings there extends a mere thread of brown glass, evidently drawn out when the internal pressure forced open the plastic wall. Occasionally minute perforations of the outer wall can be detected.

The interior wall of the fulgurite is composed throughout of a transparent highly glazed amorphous glass, full of vesicles of varying size, and with frequent patches and drops of brown and black due to the presence of iron. Microscopic examination of thin sections failed to reveal any features hitherto undescribed. In general, it can be said that there is a thin zone next to the inner wall which is generally free from vesicles. In other portions of the wall large and small vesicles are mingled in great irregularity. A few measurements taken on slide no. 3 will give a good idea of the dimensions involved. The slide shows a complete cross-section from the central portion of the tube.

Exterior diameter	Shortest	1	cm.
	Longest	1.8	cm.
Interior diameter	Shortest	.5	cm.
	Longest	1.1	cm.
Thickness of walls	Greatest	.5	cm.
Thickness of walls	Least	.1	cm.
Greatest diameter of largest vesicular space		1.2	mm.
Diameter of smallest vesicles, less than		.002	mm.

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No trace of devitrification could be observed in any of the slides. A radial arrangement of the long diameters of the large vesicles is observable in places, but is not the rule.

The fact that the fulgurite was found in sand which in its undisturbed state would be 50 ft. below the surface of the ground makes the question of its time of origin an interesting one. There are three hypotheses possible. These are:

1. *That the fulgurite was formed in Cretaceous time, while the sand was being laid down.* This would explain its lack of connection with the surface, but would necessitate the assumption that the formation was a beach or dune sand, as a fulgurite could of course not be formed in anything covered by even a thin layer of water. There is nothing inherently impossible in such an assumption. The Raritan formation is described as one which was formed near shore, under rapidly changing conditions, in brackish or fresh water, and which is to be considered of estuarine or littoral origin.* The clearly assorted character of the no. 3 sand and the cross-bedding of the limonite layers might point to a beach origin. If this were the case, the fulgurite could very well have originated at the time of the laying down of the sand. There is one fact, however, which might argue against such an explanation, and that is that the limonitic layers through which the fulgurite passed are of course of secondary origin. At what time in geological history they reached their present thickness is a question which it would be hard to answer. It is well known, however, that iron buried in sand for only a few years has cemented the grains all around it into a solid mass.

2. *That the fulgurite was formed at some time subsequent to the laying down of no. 3 sand, either before or after the Pensauken sands and gravels were deposited.* This seems improbable, because it would assume the formation of a tube 60 to 70 ft. long, the upper 45 to 55 ft. of which had subsequently been destroyed in some way.

3. *That the fulgurite was formed by lightning striking the side of the bank since the digging commenced.* This is probably the most reasonable hypothesis, but it is hard to understand why the lightning after having entered the bank should have traveled 15 ft.

* See N. J. G. S., Vol. VI., 1904, p. 164.

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nearly horizontally and parallel to the face of the bank, as it would have to have done if Mr. Crossman's observations were accurate.

The question of the time of origin will have to be left in this unsatisfactory condition, as only a careful study of the relations of the fulgurite to the sand at the time it was dug out would make a more definite answer to the question possible. The possibility of finding fossil fulgurites in undisturbed sandy strata of Mesozoic or even Paleozoic age is one which ought to be considered, however; it does not even seem improbable that a fulgurite might be filled with sand or clay and preserved as a cast. In this case its irregular branching course would very much resemble some of the problematical organisms found in the older sandstones. The identification of a fossil fulgurite in any formation would be of considerable diagnostic value, as it would be an absolute proof that this formation was not under water at the time of the formation of the fulgurite.

Since the writing of the foregoing there has come to my notice an article in the "Princeton Alumni Weekly"[59a] giving a short description of three fulgurites obtained from the same locality as the one which is the occasion of this paper. These specimens, the largest of which is 6 feet, 4 inches long, are on exhibition in the geological museum at Princeton University. According to this article, they were all found in the No. 3 sand, and in no case extended into the overlying Pensauken formation. This would seem to strengthen the theory that some at least of these fulgurites are of great age, according to Dr. Wm. J. Sinclair, who is quoted in the Alumni Weekly article, probably post-Cretaceous and pre-Pleistocene.

Historical Sketch and Bibliography.*

The first person to recognize the power of lightning as a geological factor seems to have been Horace Benedict Saussure,[1] who in the fourth volume of his work on his travels in the Alps, published in 1786, tells of his guides bringing him pieces of granite

* In the bibliography all the accessible articles have been included which had to do with lightning as a geological factor. In the historical sketch details are chiefly given of those which concern sand-fulgurites. The small figures placed above the line after the names of authors refer to correspondingly-numbered items in the bibliography.

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covered with small black vitreous drops and bubbles, which they had found near the summit of one of the outlying peaks of Mont Blanc. His first thought was that here he had a proof of the existence of igneous action in the Alps, but the merely superficial position of the vitreous material caused him to give up this hypothesis. "I despaired of learning the cause of this singular phenomenon," he says, "until I recalled that I possessed a piece of brick, struck by lightning, and of which the surface was covered with bubbles resembling those of my granite."

In order to test the validity of this new hypothesis, Saussure carried out an experiment which seems to have been the first and last of its kind. In a glass vessel he adjusted a piece of soft "laminated horn stone" in such a way that the spark from a battery of Leyden jars could be discharged through it. In order to intensify the action of the spark, he filled the vessel with oxygen, "dephlogisticated air." Of course a violent explosion resulted from the spark, and Saussure was gratified to find on portions of the shattered rock small vitreous bubbles, some entire and transparent, others broken open by the explosion of their contained vapor.

The account by William Withering[2] in 1790 of the finding of fused pebbles and irregular hollow masses of fused sand at the foot of a tree which had been struck by lightning, seems to be the first case in which the action of lightning could be actually proved. A man had been killed as a result of the same discharge and a benevolent nobleman determined to erect a tablet warning the passerby against the danger of seeking protection under trees during thunderstorms. It was while digging for the foundation of this tablet that the evidences of the action of the lightning were traced into the ground. When the matter was brought up before the Royal Society it was suggested by Watt that the hollows were occasioned by the expansion of moisture while the fusion existed.

The first finding of extended lightning tubes recognized as such was in Germany in the sand dunes of the Sennerheide near Padderborn. The finder, a Dr. Hentzen, reported his discovery through Voigt[3]; the credit of recognizing the tubes as the result of the action of lightning is to be given, however, to Hentzen. The articles by Brückmann[4] in the following year have not been acces-

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sible, but from the repetition of the "sogenannten" in his titles, I should judge that they were of a skeptical nature.

The "vitreous tubes found near to Drigg in Cumberland"[5] remain to this day the largest and among the most interesting ever discovered. Three of these tubes were found in a sand hillock within an area of fifteen square yards. One of them was traced perpendicularly to a depth of 30 feet, where it was broken and lost while still one half inch in diameter. One foot from its lower end it struck a pebble, from which it glanced at an angle of 45 degrees with the vertical and then resumed its perpendicular course. The stem is described as being "irregularly angular like a vegetable stalk much contracted by drying," and "rugged with deep longitudinal interrupted furrows, like the bark of an elm." The interior vitrified matter was "whitish, with specks of dark olive color and a few air blebs." The creasing of the stem was attributed to compression due to the rapid contraction of the heated vapor on cooling. A few years later Edward L. Irton[9] in a letter to the Geological Society tells of the rediscovery of the lower part of this tube. It was traced about ten feet further, and terminated in a bed of wet sand. Because of many small pebbles in the sand the tube was much contorted and branched, and in a thin layer of pebbles formed a fused mass two and one half inches in diameter. This tube, then, was 40 feet long and had a maximum diameter of 2½ inches. An excellent plate with nine figures accompanies the later of the two articles.

In 1817 appeared the first comprehensive paper on the subject. Karl Gustav Fiedler,[6] then a student at Göttingen, took up the matter at the instigation of one of his professors. He went over the dunes in the Sennerheide with Hentzen, the original discoverer in that locality, and made several new finds. He notes the facts that the sand near the tubes was turned red and that some tubes were completely closed in places. Melted lumps of quartz sand the size of a hazel nut were found near the end of one of the tubes. He considers possible theories of origin aside from that in which lightning is made the cause. These are (1) that the tubes are incrustations of roots; (2) that they are of concretionary origin, "sinter-like or other tubular shaped products of the mineral kingdom"; (3) that they are the former dwellings of sea-organisms

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of the class of worms (*Serpula, Corallia*). All these he dismisses in favor of lightning. He suggests, because of the similarity of the cross section of the irregular thick walled tubes with the Lichtenberg figure for positive electricity, that there may be a difference in the shape of tube formed by electricity of different signs; that the irregular thick-walled tube is due to positive electricity, and the rounded thin-walled one to negative.

Fiedler's paper aroused great interest in Germany, and between 1817 and 1823 there were thirteen papers published on the subject. There has probably never been a more ardent searcher for the fulgurites than Fiedler himself. He spent a great deal of his spare time tramping over the sand dunes, and would even crawl on his hands and knees for hours if he thought he was in a promising neighborhood. On one occasion he was almost buried alive by the caving in of sand during the digging out of a fifteen-foot tube. In a paper published in 1819[7] he tells of finding two groups of branching fulgurites in a new locality, near Rheine. The branching increased with the depth, and some branches were turned upwards. One quarter inch of red sand surrounded the tubes, and continued down several inches from their ends. To explain the frequent occurrence of the fulgurites in groups he suggests either that broken and scattered surficial pieces of one individual are taken for separate tubes, or that the upper part of a branched tube may be lost, and the branches be considered as separate individuals. He argues against a necessarily prehistoric origin of the tubes.

His next contributions tell of the finding of fragments of tubes in the sand hills near Dresden[11] and later of the digging out to its end of a 16½-foot tube,[13] the pieces of which were subsequently recemented and placed in the Royal Mineralogical Museum at Dresden. The cross-fractures due to the rapid cooling of the melted glassy mass, divided the tube into pieces one-fourth inch up to several inches long, and were much more frequent in the rough thick-walled type. In very thin-walled tubes there was much less cross-fracturing, but many longitudinal cracks.

In 1823 Fiedler[17] tells of the finding of a tube, six feet long, which ended in a hollow knot in a clay layer. There were many openings in the knot, and from these could be traced out branching lines along which the clay had been colored red. The tube

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was completely closed in places; a middle point was evident, however, from which long bubbles in the glass radiated out toward the periphery. In 1843 he exhibited a short branched tube,[22] found near Dresden, before the Academy of Sciences at Paris. One of the academy members[23] made a partial analysis of the sand in which the tube was formed, and found $CaCO_3$, Al_2O_3, and oxides of iron present in small quantities.

Most of Fiedler's articles were published in the *Annalen der Physik,* at that time edited by Dr. L. W. Gilbert, who himself became interested in the subject. In 1819 he published a paper[8] telling of coming across, in the Royal Mineralogical Museum at Dresden, undoubted fragments of fulgurites labeled "*Osteocolla Masslensis.*" The specimens had been classified by a former curator of the museum, at a time when the mineral kingdom, as well as the animal and vegetable, had its families, genera and species. *Osteocolla* was the fourth genus under the family *Morochtus,* which was the first of eighteen families into which the earthy minerals were divided. In "Terræ Musei Regii Dresdensis, quas digessit, descripsit, illustravit Dr. Christ. Gottlieb Ludwig" published in 1749, *Osteocolla Masslensis* is the first species described under the genus, and reference is given to "Maslographia, oder Beschreibung des schesischen Massel . . . von Leonh. David Hermann, Pfarrer zu Massel" published in Brieg in 1711. Gilbert obtained this work, and from it we learn that undoubted fulgurites were found in Germany as early as 1706. A few quotations from this earliest notice of the subject are interesting as showing how the good pastor mingled fact and fancy in his descriptions:

"The vitreous tubes are similar to melted glass or molten iron. They grow in yellow sand upwards out of the depths of the earth. . . . The tube is sometimes thick as a finger or thumb, sometimes as a feather quill, and the deeper one goes down the thicker and stronger it becomes. The material is very soft while in the earth; it is, however, soon made hard by the air. . . . It is not often found on the surface, but only if one goes several ells deep into the earth. In May or June it is forced by nature to bore up into the surface, and strike through the sand, and its end hereupon either breaks off of itself or is struck off by the passing over

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it of men, animals, or wagons, and some beautiful pieces are found. Sometimes, if one knows them and is on the lookout, they can be seen shining forth out of the earth. In this way I discovered some tubes in 1706. I could not dig down deeper than six ells, because the men, who were doing the digging, came upon a spring and ran danger of becoming buried. . . . Without doubt this growth is the fruit of a subterranean fire whereby are generated not only these tubes of melted and flowing sand, but by which also the two brooks at Massel and Ellgut, between which the tubes are found, become warmed in winter."

In this article Gilbert also recounts the finding of fulgurites in the sandy plains of Bahia in Brazil, by Professor Schwagrichen, and Humbolt's discovery of fused surfaces and tubes in a trap porphyry on a peak in Mexico. He also mentions the fact that Dr. Clarke, in his inaugural address as professor of mineralogy at Cambridge, argued for the concretionary origin of the tubes found at Drigg. The paper by Gilbert published in 1822,[14] is practically a repetition of the preceding one.

Arago,[10] in 1821, reviewed the subject to date, and presented a communication from Ramond announcing the discovery of rock-fulgurites in several localities in the Pyrenees. In 1822 Pfaff[15] tells of the finding of a sand-fulgurite on the island Amrum at a spot where the lightning had been seen to strike. Böttiger,[16] in the same year, takes the view that the ancients must have had knowledge of fulgurites, as an important class of soothsayers were known as "fulguriatores." It was part of their duty to carry out propitiatory ceremonies on the spot where the lightning struck, and in this connection Cicero uses the expression "condere fulmina," "to dig up the thunder bolts."

In 1823, besides the article of Fiedler[17] already mentioned, there was published a short notice by Hagen[18] of the finding of a tube at the bottom of a tree which had been struck; both these articles are summarized in the French *Annales de Chimie et de Physique.*

In 1827 Poggendorf[19] quotes from the narrative of some English travelers in which they tell of the finding of lightning tubes on the southern border of the Sahara. They were not recognized as such, however, but were considered to be of concretionary origin, and due to the action of wind and rain upon the sand.

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In 1828 the first attempt to produce tubes artificially was successfully made. Three Frenchman, Beudant, Hachette, and Savart,[20] discharged a battery of Leyden jars through some powdered glass packed in a hole in a brick, and obtained tubes resembling in every way the natural product, 2.5 mm. long with an internal diameter of .05 mm., and an external one varying from .3 mm. to 1.5 mm. By mixing some sodium chloride with the glass, these dimensions were somewhat increased.

Charles Darwin,[21] in his account of the voyage of the Beagle, tells of the finding of groups of fulgurites in sand dunes near the shores of the Plata. The longitudinal furrows he ascribes to the compression from the surrounding sand, and the occurrence of the tubes in groups to the forking of the lightning into separate branches before striking.

The theory of the concretionary origin of the sand tubes seems to have been quite persistent. In 1859, Wicke[24] quotes from "Handwörterbuch der reinen und angewandten Chemie," vol. 1, p. 873, 1842, in which this view is upheld; and then tells of the striking of lightning on a river bank, very near several workmen in a boat. They immediately went to the spot, and found two tubes close to each other penetrating 1½ feet of sand and disappearing in a peaty layer underneath.

The first case of the occurrence of a fulgurite in the United States to be noted was in 1861. Hitchcock[25] tells of the finding of fragments of a tube by Dr. Cobb at Northfield Farms, Mass. In 1865[26] and 1866[27] notices were published of the occurrence of a 22-foot tube in a fine dry sand at Macclesfield, England.

In 1868 Rollman[28] published an instructive paper on the artificial preparation of lightning tubes. He used powdered sulphur as the medium through which sparks of varying intensity from batteries and Leyden jars were passed. He found that the structure of the tubes depended on the intensity of the electric discharge, and on the tightness with which the sulphur was packed, and had nothing to do with the positive or negative character of the discharge, as Fiedler had suggested. The weaker discharges produced thin-walled, well-rounded tubes; the stronger, wider ones, thicker walled and more irregular. The more loosely the material is packed, the wider the tubes become, and in very loose material the

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wall of the tube may appear only as a network of fine columns divided by many longitudinal cracks. If a plate is substituted for a point as the receiver for the discharge, branching is much increased. The tubes are formed by the mechanical thrusting to all sides of the material penetrated; the looser the material the more mechanical action and less fusion there will be; at the surface of loose material a cone-shaped cavity is formed with no fusion whatever.

In 1870 Abich's[29] account of the discovery of rocks at the summit of Little Ararat thickly penetrated by glass-walled lightning tubes was published. A fine specimen of this rock is now on exhibition at the American Museum of Natural History. In 1872 Rose[30] exhibited specimens obtained by Abich and Humboldt before the German Geological Society.

In 1873 C. Scholz[31] published an analysis of a fulgurite found in a very hard compact marl, together with the composition of the marl. This is either a very remarkable case, or more probably the specimen which Scholz examined was not a fulgurite, but a concretionary structure of some kind. According to his analysis the marl contained 28.25 per cent. SiO_2 and 43.48 per cent. of carbonates, while the fulgurite had only .83 per cent. SiO_2 and 96.2 per cent. of carbonates.

The article by Harting[32] published in 1874 I have not been able to examine. From a partial summary in the *Annales de Mines*[33] of the following year, it seems that it contained a review of the literature to date, with an account of the formation of two fulgurites close to each other where lightning had struck in a corn field. The following analysis is given SiO_2 90.2 per cent., Al_2O_3 .9 per cent., Fe_2O_3 .7 per cent., CaO .1 per cent., MgO .5 per cent., K_2O .5 per cent., Na_2O .6 per cent., insoluble in HCl .9 per cent., carbonaceous and lost 5.6 per cent. In addition the observation is made that fulgurites are not generally found at the summit of sandhills, but more often in the little valleys which separate them. This is ascribed to the presence of water in the valleys.

Roemer,[34] in 1876, tells of the great abundance of fulgurites near Olkusz in Silesia. In an area measuring 200 by 100 feet, 26 fulgurites were found, mostly associated in groups; in one case five occur in a line 25 feet long. Roemer brings out the point that

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the lack of vegetation in a given locality does not form an especial attraction for lightning; the fulgurites seem to be more abundant in such localities merely because they are more easily discoverable. That the cultivation of the earth offers no hindrance to the formation of tubes, is shown through the various cases in which lightning has been seen to strike in cultivated fields with the subsequent discovery of tubes in the place affected.

In 1879 Planeth[35] published a short notice of the finding of an ordinary thin-walled tube in a dampish sand in Mecklenburg.

In 1882 Gümbel[36] told of the finding of several fulgurites in the Libyan desert. In some tubes grains of quartz were abundantly scattered in the glass, and completely enclosed by it. A series of darker tubes were characterized by the extreme irregularity of form, due to the presence of iron and magnesia in the glass, which caused it to be more fluid and thus more easily deformed. The glass of the first mentioned tubes possessed less specific gravity than the quartz. There were no signs of devitrification.

In 1883 Bastelaer[37] tells of the formation of a fulgurite in a pile of building sand in the presence of several witnesses. In the same year Wichmann[39] published an important paper in which he gives the results of microscopic examination of fulgurites collected by Roemer, Harting and Abich. The glass is in all cases completely free from crystalline products and foreign mineral inclusions. Large numbers of steam pores are included, the larger elliptical in shape with their longer axes radially directed. The smaller bubbles are predominantly circular; the bubbles decrease in number near the inner margin. On the outside the fulgurite is bounded by half fused quartz grains and other components of the sand. The quartz grains may have one end unaltered, the other changed to an opaque, apparently extraordinarily finely vesicular mass. The radial arrangement of the steam pores, their manifold deformation, and the external irregularities of the tube, are all due to the compression of the originally round tube by the outer air. Analysis showed 91 to 96 per cent SiO_2 in various specimens. Some rather baseless criticisms are made of Gümbel's[36] article, which Gümbel replied to in a communication[41] published the following year.

Diller,[40] in 1884, suggests that the word fulgurite be restricted

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to the substance resulting from the electric fusion, the expression lightning tube to the tubular form in which the fusion takes place. He notes the occurrence of tubes in the sand of Santa Rosa Island, near Pensacola, Fla., which under the microscope showed a clear amorphous glass, with gas cavities, a light brown clouding due to oxide of iron, and occasional remnants of quartz grains. He also tells of the finding of fulgurite in the form of superficial coatings and tubes in a hypersthene basalt on the summit of Mt. Thielson, Oregon.

In 1885 Rutley[42] described fulgurite in the form of superficial globules and patches of brownish black and white glass from Mont Blanc.

In 1886, Merrill[43] took up the question of fulgurites in sand and described occurrences at Santa Rosa Island, Fla., and Union Grove, Ill. At the latter place several tubes occurred within an area of fifty square feet at the top of a sand knoll. The largest was 3½ inches in diameter, and was traced 7 feet vertically into the sand. Bulbous enlargements occurred where the tube crossed thin interstratified beds rich in iron. In two cases where analysis was made, the silica content of the sand was found to be less than that of the fulgurite (95.91 and 91.66 per cent. in the fulgurites, as compared with 90 and 84.83 per cent. in the sand). This can be explained by assuming that minerals of the poorest conductivity fused the easiest because heated hottest. The branches and wings are original structures, and not due to the collapse of the walls. The irregularity of the tubes near the surface is due to the exceedingly energetic action of the current and to the lack of homogeneity of the material. A bibliography fairly complete up to 1885, with short notes, is appended.

In 1889 Rutley[44] described specimens of glaucophane-epidote schist collected from the summit of Monte Viso, upon which crusts and furrows of fulgurite glass had been formed. In 1890, R. C. Hills[44a] reported a similar occurrence on an augite-biotite-diorite from the Spanish Peaks, Col.

In 1892 Bailey[45] examined a small fragment of a sand fulgurite from Waterville, Maine. He agreed with Merrill that the wings are merely a single layer of glass not due to the collapsing of the tube, but to the selective power of the electricity.

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Geinitz,[46] in 1893, tells of the digging out of a complete tube from the Ribnitzer Heide in Mecklenburg. The pieces were re-cemented and a photograph of the complete tube is given. Analysis showed that the sand and the fulgurite were almost identical in composition.

	Sand.	Fulgurite.
SiO_2	93.6	93.8
Fe_2O_3 / Al_2O_3	3.9	3.8
Na_2O	1.3	
K_2O	.7	
CaO	.3	.6
H_2O	.45	

In the same year Rutley[47] described pieces of sand fulgurite from near Griquastad in South Africa. In connection with the idea that the wing-like projections are primary structures and not due to the collapse of the tube he makes the following suggestion. The photograph made by the spark from an induction coil when the positive pole is brought over the sensitized surface of a glass plate, shows that the plate is perforated by the spark, but that a portion of the discharge is dissipated over the resisting surface of the plate. The outer edge of the affected portion of the plate gives a very irregular outline similar to the outline of the cross-section of an irregular fulgurite tube. Assuming that lateral extensions, somewhat similar to those photographed on the plate, occur at extremely small intervals along the course of a lightning flash when it passes into loose sand, the distribution of the electric discharge might be represented by a succession of these photographs impaled on an irregularly bent wire. The lack of homogeneity in the sand would further affect the shape of the cross section.

In a short note published in 1895 Gourdon[48] says that he has found rock fulgurites at from 12 to 15 different places in the Pyrenees. In 1896, Aston and Bonney[49] described fulgurites discovered in a nickel-bearing serpentine from the summit of the Rifflehorn.

In 1896 and 1897 Richardson[50] published a series of articles consisting chiefly of a historical review of the subject up to 1896. In most cases he gives no references to the original articles, and there

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are many inaccuracies in the proof reading. These articles remain however the most complete summary of the subject yet published.

In 1899 Bonney[51] described specimens of hornblende andesite found in Chile at a height of 20,260 feet which showed tubes and channels of fulgurite. In the same year Hobbs[52] studied a sand fulgurite which had been found in a sand knoll at Cutler, Wis. He observed that the corrugations of the exterior formed a dextro-rotary helix, and cited Hittorf, who found that in case of a negative discharge nearly parallel to a line of force the spark takes the form of a dextro-rotary spiral and wraps itself about the line of force. He does not think, however, that the earth's field would be strong enough to effect such a change. Artificial fulgurites were produced by immersing carbon electrodes in a bath of sand, and passing a current through them. Corrugated branched tubes, 2 to 3 inches long and ½-inch in cross section were thus produced.

In 1901 Hallock[53] witnessed a lightning discharge at Split Rock, on Lake Champlain, which subsequent examination showed to have split and superficially fused the gneiss around a pine tree which had been struck. In the same year, Julien[54] published the results of a very careful microscopic study of the structure of fulgurites; his material consisted of a sand-fulgurite from Poland, and rock fulgurites from Split Rock, Lake Champlain, Lesser Ararat, Armenia and Central Butte, Little Missouri Buttes, Wyo. New points which he brings up concerning sand-fulgurites are: (1) Careful search fails to reveal any water in the bubbles which occur in such large numbers in the glass; therefore the water vapor derived from the moisture in the sand has been mostly expelled in the explosion and has probably far less to do with the expansion of the lumen and the formation and compression of bubbles than the elastic force evolved by the sudden heating of the large volume of air occupying the interstices of the sand grains. (2) The longer axes of the elongated vesicles are disposed radially; this is due to a strong lateral compression of the vesicles as a result of the lateral contraction on relief from the outward pressure. (3) This radial arrangement has been reported previously only in connection with two rock fulgurites, in each of which partial devitrification had taken place. This may show that the bubbles retain their distorted forms only in the more viscous crystallite laden

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glass. (4) Glass threads, connecting adjacent sand grains or projecting as if broken are due to the outward jerking of the grains when in a viscous state. (5) With the high power, a general distribution of crystallites was observed. This is the first sand fulgurite in which this feature could be detected; its occurence is attributed to the high proportion of feldspar in the original sand, which would give the glass a high viscosity. (6) It is unlikely that any selective power could have been exerted among the sand grains through their slight variations in fusibility or conductivity. All within a radius of a few millimeters were suddenly and completely fused. The molten mass of the wall became a supersaturated solution of feldspar with strong solvency toward any external quartz grains within its reach, through the tendency to form more acid silicate. Such action probably accounts for the increased amount of silica which has been determined in fulgurite glass over that in the original sand.

In 1901 and 1902 articles were published on examples of lightning as a geological factor by Anderson[55] and Fredholm[56] which I have not been able to examine.

In 1902 Geinitz[57] described lightning tubes from Liessow and Goldberg in Mecklenberg. The first of these, from Liessow, is interesting in that it had divided about a root, which it burned and coated with glass; the second, from Goldberg, because the tube had been formed in a very damp sand and the only traces of fusion consisted of isolated white quartz grains and small white melted grains.

In 1905 Berg[58] tells of lightning striking in a potato field. The plants were killed over an area 4 m. in diameter. No trace of lightning was found in the humus layer, which was 25 cm. thick. Beneath this, however, in a diluvial sand a tube was found with very thin walls broken through by longitudinal fissures and lattice-like cracks. The tube ended in a wet boulder clay, in which, however, irregular traces of fusion could be traced to a depth of 12 cm.

The paper by Barnett,[59] published in 1908, I have included for the sake of completeness. It takes up an example of the disruptive power of lightning, and gives a few references to other similar occurrences.

In 1909 Miss Butcher[60] made some experiments on the artificial

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production of fulgurites, in which she passed a spark from a l
tery of Leyden jars through very fine glass powder packed i
hole in a paraffin block. Her results and conclusions are m
the same as those reached by Rollman. The length and thickr
of the tube depended upon the energy of the spark, an abr
oscillatory spark formed no tube. If one electrode was a p
and the other a flat plate, the branching was always toward
plate. In nature, the flat plate would be represented by the m
lower strata of the soil. The positive or negative character of
discharge made no determinable difference in the tubes. La
bored, thin-walled tubes result from violent explosive effects
small amount of fusion. In extreme cases the walls may be le
a mere network of fused material.

SUMMARY.

Occurrence.—Almost all of the sand-fulgurites reported h
been found in dunes and desert areas, but there is abundant
dence that they can be formed equally well in a sandy soil cov
with vegetation and humus. They are however rarely discov
in such circumstances; generally, only if the lightning
charge has been witnessed, as they leave no trace in the hu
In most cases they do not terminate until they reach water lev
some damp stratum which acts as a conductor.

The fact that they often occur in groups was explained by
win as being due to the branching of the lightning before r
ing the ground. Recent investigation has shown that many l
ning flashes consist of a series of discharges which follow the
path, and that when a wind is blowing this path may be m
along, so that what seems like a single broad flash may be a s
the individuals of which would strike in different places.*

Size and Macroscopic Appearance.—Fulgurites have been f
up to 40 feet long and 2½ to 3 inches in diameter, but these di
sions are exceptional. In general, they follow an irregular br
ing course and have a very rough exterior, corrugated longit
ally, and coated with partially fused sand grains. The in
wall is lined with a clear, shining glass streaked and spotted

* See *Electrical World and Eng.*, Vol. 34, 1899, pp. 651–652, for phot
and account of flash showing fourteen distinct bands.

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black and brown according to the abundance of the iron-bearing minerals. Away from the immediate inner wall the glass is generally very vesicular. This inner wall partakes for the most part in the irregularities of the outer surface. There also occur tubes of thinner walls and with nearly circular cross-section. In extreme cases these are simply a round hole with a mere network of fused material on the walls.

Microscopic Appearance.—In thin sections under the microscope the fulgurite material is shown to be a clear amorphous glass, filled with vesicles of varying size and shape, and sometimes containing unfused quartz grains. There is generally a narrow zone next to the lumen practically free from vesicles. In only one case of a sand fulgurite has any trace of devitrification been observed. The microscope shows that the irregular wings and protrusions of glass which sometimes occur cannot be due to the collapse of the walls, since there is no trace of any line of separation.

Manner of Formation.—Fulgurites are formed in dry sand by lightning discharge. The sand layer can be looked upon as a dielectric lying between a discharging point above, and a receiving plate, the water level or a wet stratum, beneath. The lumen or opening is formed primarily by a mechanical thrusting aside of the material in the path of the discharge, and in very loose material at the surface this mechanical action may be so great that no fusion takes place. As the depth increases, in loose material there will be found a thin walled tube with nearly circular outline. In compact material the bore of the tube is smaller, and the walls thicker and much more irregular. The extent of these irregularities depend upon the intensity of the discharge and the homogeneity of the material. The discharge will always follow the path of least resistance, and may be deflected by striking a pebble or root. Branching is irregular, and probably depends on the structure of the material through which the discharge is passing. That the first expansion has been succeeded in some cases by a contraction is shown by the radial elongation of the large vesicles. This contraction is due to the decrease in internal pressure brought about by the rapid cooling of the heated air and vapor.

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A LIST OF NEW CRYSTAL FORMS OF MINERALS.

By H. P. WHITLOCK.

The notable advance which has been made in the study of mineral crystallography during the last two decades has rendered necessary to the worker in this branch of science a considerable extension of the list of crystal forms of minerals published in Goldschmidt's "Index."* The writer has compiled, for his own use from various sources, a list of those forms which have been recorded since the publication of the above work. This compilation, which was begun as a card catalogue, has grown to such proportions that it seemed justifiable to render it available to other students of this most interesting branch of mineralogy. In doing so the compiler is keenly conscious of the possibility of omissions and errors and will gratefully welcome additions and corrections. A number of the forms listed will be found in Goldschmidt's "Krystallographische Winkeltabellen."† It has, however, seemed advisable to include these, since the present list is intended as an addition to the "Index."

Acmite-Aegirite.

W. C. Brögger. Zeitschr. f. Kryst., 1890, *16*, 658.

Prisms: $V(11.1.0)$, $\chi(510)$, $f(310)$, $L(730)$, $W(16.15.0)$.

Orthodome: $H(\bar{3}02)$.

Pyramids: $\lambda(\bar{3}31)$, $\pi(\bar{5}51)$, $O(\bar{6}61)$, $\Omega(881)$, $Q(\bar{1}61)$, $K(\bar{1}91)$, $k(\bar{3}12)$, $s(\bar{1}11)$, $v(221)$, $\Delta(592)$, $\varepsilon(\bar{4}.10.3)$, $\Lambda(451)$.

O. B. Böggild. Min. Grönland, 1905, 379.

Pyramid: $(\bar{2}21)$.

Adelite.

Hj. Sjögren. Geol. Fören. Förh., 1891, *13*, 781.

Pinacoids: $a(100)$, $c(001)$.

* Goldschmidt, V., "Index der Krystallformen der Mineralien," Berlin, 1886–91.

† Goldschmidt, V., "Krystallographische Winkeltabellen," Berlin, 1897.

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Prism: $m(110)$.
Clinodome: $f(011)$.
Pyramid: $d(221)$.

ALAMOSITE.

Monoclinic.

C. Palache and H. E. Merwin. Am. Jour. Sci., 1909, *27*, 399.
Pinacoids: $c(001)$, $a(100)$, $b(010)$.
Prism: $m(110)$.
Domes: $v(101)$, $g(011)$.
Pyramids: $p(\bar{1}21)$, $r(121)$.

ALBITE.

C. Dreyer and V. Goldschmidt. Medd. om Grönland, 1907, 34.
Prism: $K(350)$.
Brachydomes: $\vartheta(0\bar{4}1)$, $\mathbb{Z}(0\bar{5}1)$?
Pyramids: $\Gamma(\bar{1}13)$, $\Lambda(\bar{3}32)$, $\xi(\bar{1}51)$, $\phi(\bar{2}11)$, $X(\bar{2}91)$? $\omega(\bar{3}12)$, $Q(1\bar{5}2)$.

H. Bowman. Min. Mag., 1902, *13*, 115.
Prism: $Z(120)$.
Pyramids: $\Upsilon(\bar{3}11)$, $\chi(\bar{2}\bar{4}1)$.

ALTAITE.

A. S. Eakle. Bull. Geol. Univ. Cal., 1903, *13*, 278.
Trapezohedron: $\beta(322)$.

ANALCITE.

M. F. Heddle. Trans. Edin. Geol. Soc., 1897, *7*, 241.
Trisoctahedron: (332).
Hexoctahedrons: $z(543)$, $t(421)$.

ANAPÄITE.

Triclinic.

A. Sachs. Sitzungber. d. k. Akad. d. Wiss. Berlin, 1902, 18.
Pinacoids: $a(100)$, $c(001)$.
Prism: $m(1\bar{1}0)$.
Pyramid: $o(\bar{1}\bar{1}1)$.

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ANCYLITE.

Orthorhombic.

G. Flink. Medd. om Grönland, 1899, *14*, 235.
Domes: $d(101)$, $e(011)$.

ANDALUSITE.

P. E. Haefell. Zeitschr. f. Kryst., 1894, *23*, 551.
Prism: $i(320)$.
Domes: $t(013)$, $v(054)$.
Pyramid: $x(112)$.

ANDESINE.

K. Busz. Neues Jahrb. f. Min., 1898, *1*, 36.
Prism: (120).

ANDORITE.

Orthorhombic.

G. T. Prior and L. J. Spencer. Min. Mag., 1897, *11*, 286.
Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prisms: $\phi(610)$, $\psi(510)$ $n(210)$, $o(320)$, $m(110)$, $l(230)$, $k(120)$.
Macrodomes: $h(102)$, $\Theta(305)$, $\sigma(203)$, $\kappa(405)$, $f(101)$, $e(302)$, $\lambda(301)$, $\mu(902)$.
Brachydomes: $x(011)$, $\nu(043)$, $\pi(032)$, $\gamma(021)$, $y(031)$.
Pyramids: $v(112)$, $\chi(223)$, $p(111)$, $z(332)$, $q(221)$, $\rho(331)$, $s(211)$, $\delta(364)$, $r(121)$, $\epsilon(362)$, $\omega(132)$, $\beta(131)$, $a(162)$, $\zeta(2.21.7)$.

L. J. Spencer. Min. Mag., 1907, *14*, 308.
Brachydomes: $w(035)$, $n(041)$.
Pyramids: $B(441)$, $C(243)$, $D(241)$, $\xi(312)$, $A(321)$, $E(261)$.

ANGLESITE.

P. Hermann. Zeitsch. f. Kryst., 1904, *39*, 463.
Prism: $\Omega(540)$.
Pyramids: $\eta(125)$, $\Sigma(127)$.

P. Jeremejew. Verh. Min. Ges., 1892, *29*, 174.
Dome: (016).

L. J. Spencer. Min. Mag., 1897, *11*, 197.
Pyramid: $D(255)$.

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ANHYDRITE.

F. Bascom and V. Goldschmidt. Zeitschr. f. Kryst., 1908, *44*, 65.
Pyramid: $p(115)$.

ANORTHITE.

V. Hulyàk. Zeitschr. f. Kryst., 1904, *40*, 504.
Domes: $G(\bar{4}05)$, $F(\bar{2}05)$.
Pyramids: $V(\bar{1}31)$, $H(421)$, $K(\bar{2}43)$, $L(\bar{2}\bar{4}3)$.

APATITE.

H. L. Bowman. Zeitschr. f. Kryst., 1903, *37*, 111.
Prisms: $l(43\bar{7}0)$, $W(52\bar{7}0)$, $W_1(72\bar{5}0)$.
Pyramids: $P(2.\bar{2}.0.19)$, $Q(20\bar{2}7)$.

K. Walter. Neues Jahrb. f. Min. B.-B., 1907, *23*, 581.
Prisms: $B(54\bar{9}0)$, $K(10.9.\bar{1}9.0)$, $K_1(19.\bar{9}.\bar{1}\bar{0}.0)$.
Pyramid: $D(13.0.\dot{1}\dot{3}.4)$.

K. Busz. Centralbl. f. Min., 1906, 755.
Pyramids: $\lambda(4.0.\bar{4}.21)$, $\beta(50\bar{5}7)$, $\delta(40\bar{4}5)$, $\gamma(8089)$.

F. Zambonini. Zeitschr. f. Kryst., 1905, *40*, 220.
Pyramid: $F(10\bar{1}4)$.

K. Zimányi. Zeitschr. f. Kryst., 1904, *39*, 508.
Pyramids: $e(7.0.\bar{7}.11)$, $f(20\bar{2}3)$, $g(70\bar{7}9)$, $j(70\bar{7}8)$.

P. Jeremejew. Verh. Min. Ges., 1895, *33*, 65.
Pyramid: $(80\bar{8}7)$.

F. Slavík. Abh. d. bohm. Akad., 1901, 16 = Zeitschr. f. Kryst., *35*, 498.
Pyramid: $O(12.0.\bar{1}\bar{2}.5)$.

C. Vrba. Zeitschr. f. Kryst., 1889, *15*, 449.
Pyramid: $t(1.1.\bar{2}.12)$.

G. Struever. Zeitschr. f. Kryst., 1895, *24*, 316.
Pyramids: $A(11\bar{2}3)$, $R(52\bar{7}3)$.

G. Struever. Riv. d. Min. Padua, 1899, *22*, 80 = Zeitschr. f. Kryst., *34*, 285.
Pyramid: $p(4156)$.

R. H. Solly. Min. Mag., 1887, *7*, 141.
Pyramid: $b(22\dot{4}\dot{3})$.

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APOPHYLLITE.

P. I. Ploner. Zeitschr. f. Kryst., 1890, *18*, 337.

Second Order Pyramids: (1.0.60), (1.0.40), (1.0.30), (1.0.24), (1.0.20), (1.0.18), (1.0.14), (1.0.13), (1.0.12), (1.0.11), (2.0.21), (1.0.10), (2.0.19), (109), (3.0.22), (107), (2.0.13), (3.0.19), (3.0.17), (2.0.11), (3.0.16), (4.0.21), (3.0.14), (209), (104), (3.0.10), *t*(103), (307), (504), (302).

First Order Pyramids: (1.1.54), (1.1.45), (1.1.36), (1.1.27), (1.1.18), *ξ*(119), (335), (445), (556), (667), (778), (889), (10.10.11), (11.11.12), (13.13.14), (17.17.18), (50.50.51), (25.25.24), (443), *k*(332), (441), (551).

Ditetragonal Pyramids: (13.4.4), (12.5.5), (552), (855), (544), (322), (433), (655), (933), (20.7.7), (744), (755), (766), (313), (623), (21.7.3), (12.4.3), (15.5.3).

J. Currie: Trans. Edin. Geol. Soc., 1897, *7*, 252.

First Order Pyramid: *χ*(223).

A. Hennig. Geol. Fören. Förh., 1899, *21*, 391.

First Order Pyramids: (19.19.18), (17.17.16), (15.15.14), (14.14.13), (13.13.12), (12.12.11), (10.10.9), (998), (776), (665), (554).

O. Luedecke. Min. d. Harzes, 1896, 572.

First Order Pyramid: (11.11.10).

H. P. Whitlock. School of Mines Quar., 1910, *31*, 231.

Ditetragonal Pyramid: *h*(711).

ARAGONITE.

G. B. Negri. Riv. Min. Ital., 1896, *15*, 65.

Prisms: (430), (570).

Domes: (073), (052).

Pyramids: (331), (133), (342), (7.10.3), (352), (271), (512), (9.2.16), (413), (3.2.12), (431), 24.25.1).

L. Brugnatelli. Zeitschr. f. Kryst., 1899, *31*, 56.

Prisms: (17.16.0), (11.13.0).

L. Brugnatelli. Riv. Min. Ital., 1898, *18*, 51.

Pyramid: (16.22.1).

K. Zimányi. Természetrajzi Fuzetek, 1899, 22.

Domes: Π(0.19.10), τ(0.11.3), *N*(092), *K*(0.17.1), *P*(0.19.1),

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Q(0.21.1), R(0.45.2), T(0.26.1), U(0.27.1), W(0.32.1.), X(0.35.1), Y(0.40.1).

Pyramids: $\mathfrak{a}$(551), $\mathfrak{b}$(12.12.1), $\mathfrak{g}$(21.21.1), $\mathfrak{e}$(45.4

F. Stöber. Mitth. d. geol. Land. El. Loth., 1894.

Dome: (0.15.2).

Pyramids: (231), (341), (572), (8.11.3).

Argyrodite.

(Proved to be isometric-tetrahedral by S. L. Penf

S. L. Penfield. Am. Jour. Sci., 1893, *46*, 107.

Dodecahedron: d(110).

Tetrahedron: o(111).

Trigonal Tristetrahedron: v(311).

Arsenopyrite.

F. Scheerer. Zeitschr. f. Kryst., 1893, *21*, 354.

Prism: δ(310).

Domes: ζ(0.17.2), ϵ(054).

A. Schmidt. Zeitschr. f. Kryst., 1888, *14*, 573.

Domes: β(016), α(0.1.24).

L. Colomba. Rend. Accad. Linc., 1906, *15*, 642.

Pyramid: (221).

Arzrunite.

Orthorhombic.

A. Arzruni and K. Thaddéeff. Zeitschr. f. Kryst., 18

Pinacoids: b(010), c(001).

Prism: m(110).

Dome: (021).

Pyramid: (111).

Atacamite.

G. F. Herbert Smith. Min. Mag., 1898, *12*, 15.

Prism: τ(890) or (9.10.0)?

Pyramids: ζ(443), ϕ(131), h(132), σ(332).

C. Anderson. Rec. Austral. Mus., 1908, *7*, 67.

Prism: s(120).

Pyramid: n(121).

A. J. Moses. Am. Jour. Sci., 1901, *12*, 100.

Prism: γ(150).

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Augelite.

Monoclinic.

G. T. Prior and L. J. Spencer. Min. Mag., 1895, *11*, 16.
Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prism: $m(110)$.
Domes: $x(\bar{1}01)$, $r(011)$.
Pyramids: $n(112)$, $o(\bar{1}12)$.

L. J. Spencer. Min. Mag., 1898, *12*, 1.
Prism: $g(910)$.

Axinite.

A. Offret and F. Gonnard. Bull. Soc. fr. Min., 1893, *16*, 76.
Prisms: (810), (530), (17.13.0), (11.9.0), (13.11.0). (1.41.0), $(\bar{1}\bar{7}.1.0)$, $(\bar{9}80)$, (13.12.0).
Pyramids: $(\bar{1}.1.56)$, $(\bar{1}.1.16)$, $(\bar{2}29)$, $(\bar{3}76)$, $(57\bar{2})$.

Hj. Sjogren. Bull. Geol. Inst. Upsala, 1893, *1*.
Prism: $\gamma(\bar{1}20)$.
Domes: $U(061)$, $R(081)$.
Pyramids: $Z(\bar{4}41)$, $Q(327)$, $\lambda(\bar{2}85)$.

Azurite.

G. A. F. Molengraaf. Zeitschr. f. Kryst., 1893, *22*, 156.
Dome: $\Lambda(0.1.10)$.
Pyramids: $\Gamma(263)$, $W(1.3.15)$.

W. H. Hobbs. Bull. Univ. Wis., 1895, *1*, 145.
Dome: $\mathfrak{c}(307)$, $\mathfrak{b}(\bar{2}03)$.
Pyramid: $\mathfrak{b}(9.12.8)$.

C. Steiner. Ann. mus. nat. hung., 1906, 293.
Dome: $\mathfrak{C}(\bar{3}.0.10)$, $\mathfrak{r}(\bar{4}03)$, $\mathfrak{p}(\bar{1}\bar{5}.0.8)$, $\mathfrak{M}(13.0.6)$.
Pyramid: $R(\bar{2}41)$.

K. Zimányi. Zeitschr. f. Kryst., 1892, *21*, 86.
Domes: $I(\bar{2}05)$, $T(\bar{4}05)$, $W(\bar{6}05)$.

O. C. Farrington. Am. Jour. Sci., 1891, *41*, 300.
Pyramids: $N(\bar{4}47)$, $G(\bar{3}21)$, $K(1\bar{2}.10.5)$.

G. Cesàro. Bull. Ac. Belg., 1905, 130.
Pyramids: $(\bar{2}61)$, $(\bar{1}.10.2)$.

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BABINGTONITE.

C. Palache and F. R. Fraprie. Proc. Am. Acad., 1902, *38*, 382.
Prism: $K(110)$.
Domes: $u(054)$, $v(035)$, $w(025)$, $x(305)$, $y(205)$, $\mu(\bar{1}01)$.
Pyramids: $p(111)$, $t(112)$, $i(\bar{1}12)$.

BADDELEYITE.

Monoclinic.

E. Hussak. Neues Jahrb. f. Min., 1892, *2*, 141.
Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prisms: $m(110)$, $l(230)$, $k(120)$.
Domes: $s(203)$, $t(101)$, $x(201)$.

BARITE.

J. Samojloff. Verh. Min. Ges. Petersb., 1900, *2*, *38*, 323.
Prisms: $\vartheta(910)$, $M(570)$, $n_2(7.13.0)$, $n_1(10.23.0)$.
Dome: $j(034)$.
Pyramids: $B_2(227)$, $B_3(337)$, $R_1(10.10.7)$.

A. Brunlechner. Min. Mitth., 1891, *12*, 62.
Prisms: $E(650)$, $U(4.11.0)$, $B(1.22.0)$, $R(1.30.0)$, $B_1(1.40.0)$
Domes: $A(0.16.1)$, $A_1(0.20.1)$.

A. Hamberg. Geol. Fören. Förh., *11*, 212.
Prism: (450).
Domes: (025), (035).
Pyramid: (1.23.20).

L. Colombo. Rend. Accad. Linc., 1906, 5, *15*, 419.
Prisms: $\Pi_1(350)$, $E_1(170)$, $E_2(1.10.0)$.

Pyramids: $e_1(1.1.17)$, $e_2(1.1.14)$, $\vartheta_1(727)$.

K. Zimányi. Zeitschr. f. Kryst., 1908, *44*, 162.
Domes: (047), (407).

K. Zimányi. Földt. Közlöny., 1894, *24*, 6.
Pyramid: $J(355)$.

F. Slavík. Abh. böhm. Akad., 1905, *19*, 11.
Domes: $\epsilon_2(045)$, $\epsilon_3(067)$.
Pyramids: $Y_3(1.16.16)$, $Y_2(199)$, $Y_1(188)$, $\psi(166)$, Γ_3-(1.16.24), $\Gamma(1.16.32)$, $\tau(1.12.11)$, $\mu_3(179)$, $\zeta_2(164)$, μ_2 (168), $\Gamma_2(169)$, $t_2(253)$.

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C. O. Trechmann. Min. Mag., 1886, *7*, 49.
Domes: o^7(071), $d^3/_8$(308).
Pyramids: P(344), r'(324), λ'(213), σ'(11.5.55).

G. Cesáro. Bull. soc. geol. Belg., 1886, 14, 10.
Dome: a^6(016).

G. B. Negri. Riv. Min. Ital., 1893, *12*, 3.
Domes: (1.0.25), (403).
Pyramids: (123), (157), (2.5.11), (163).

O. Herschenz. Zeitschr. f. Naturwiss. Halle, 1888, 61, 143.
Domes: V(307), S(405).
Pyramids: Y(177), $\mathfrak{b}$(1.2.40), ω(12.4.9).

O. Luedecke. Min. d. Harzes, 1896, 351.
Pyramid: $\mathfrak{i}$(1.1.26).

W. T. Schaller. Am. Jour. Sci., 1906, *21*, 321.
Pyramid: S(551).

A. Catherine. Verhandl. Geol. Reich., 1889, 107.
Pyramid: j(1.1.10).

G. Melczer. Földt. Közlöny, 1896, *26*, 357.
Pyramid: $\mathfrak{p}$(772).

K. v. Kraatz-Koschlau. Abh. Hess. G. Land., 1897, *3*, 55.
Pyramid: $\mathfrak{i}$(196).

F. Millosevidi. Rend. Accad. Linc., 1900, *9*, 336.
Pyramid: Y(152).

D. Artemieff. Bull. Soc. Nat. Moscow, 1904, *18*, 364.
Pyramid: λ_2(214).

Barysilite.

Hexagonal.

Hj. Sjögren. Geol. Fören. Förh., 1905, *27*, 458.
Base: c(0001).
Rhombohedrons: $s(10\bar{1}1)$, $r(90\bar{9}7)$.
Scalenohedron: $n(2\bar{7}94)$.

Baumhauerite.

Monoclinic.

R. H. Solly. Min. Mag., 1903, *13*, 151 and 336.
Pinacoids: a(100), b(010), c(001).
Orthodomes: $-30\,h$(30.0.1), $-25\,h$(25.0.1), $-19\,h$(19.0.1), $-25/_2\,h$(25.0.2), $-19/_2\,h$(19.0.2), $-9\,h$(901), $-17/_2\,h$

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(17.0.2), —15½ *h*(15.0.2), —5 *h*(501), —9½ *h*(902), —4 *h* (401), —7½ *h*(702), —3 *h*(301), —13⅓ *h*(13.0.5), —5½ *h* (502), —13⅙ *h*(13.0.6), —2 *h*(201), —13⅐ *h*(13.0.7), —3½ *h*(302), —7⅛ *h*(705), —4⅜ *h*(403), —7⅙ *h*(706), —13/12 *h*(13.0.12), —*h*(101), —5⅛ *g*(506), —4⅝ *g*(405), —3¼ *g*(304), —5⅜ *g*(508), —½ *g*(102), ⅖ *g*(205), —⅓ *g* (103), —¼ *g*(104), —⅙ *g*(106), —⅐ *g*(107), —⅑ *g* (109), +8 *h*(80$\bar{1}$), +15½ *h*(15.0.$\bar{2}$), +7 *h*(70$\bar{1}$), +6 *h* (60$\bar{1}$), +11½ *h*(11.0.$\bar{2}$), +5 *h*(50$\bar{1}$), +9½ *h*(902), +4 *h*(40$\bar{1}$), +7½ *h*(70$\bar{2}$), +3 *h*(30$\bar{1}$), +13¼ *h*(13.0.$\bar{4}$), +11¼ *h* (11.0.$\bar{4}$), +5½ *h*(50$\bar{2}$), +9¼ *h*(90$\bar{4}$), +11⅕ *h*(11.0.$\bar{5}$), +2 *h*(20$\bar{1}$), +13⅐ *h*(13.0.$\bar{7}$), +11⅙ *h*(11.0.6), +7¼ *h*(70$\bar{4}$), +5⅜ *h*(50$\bar{3}$), +8⅝ *h*(805), +3½ *h*(30$\bar{2}$), +4⅜ *h*(40$\bar{3}$), +5¼ *h*(50$\bar{4}$), +*h*(10$\bar{1}$), +5⅛ *g*(50$\bar{6}$), +3¼ *g*(30$\bar{4}$), +⅔ *g* (20$\bar{3}$), +5⅑ *g*(509), +½ *g*(102), +⅖ *g*(205), +⅜ *g*(30$\bar{8}$), +⅓ *g*(10$\bar{3}$), +¼ *g*(10$\bar{4}$), +⅙ *g*(10$\bar{6}$), +2/13 *g*(2.0.13$\bar{3}$), +⅐ *g*(10$\bar{7}$), +⅑ *g*(10$\bar{9}$), +1/12 *g*(1.0.12$\bar{2}$).

Prisms: 4 *r*(140), 2 *r*(120), ⅜ *r*(340), *r*(110), ⅝ *s*(980), 3½ *s*(320), ⅝ *s*(950), 2 *s*(210), 17⅛ *s*(17.8.0), 5½ *s*(520), 8⅓ *s*(830), 3 *s*(310), 10⅓ *s*(10.3.0), 11⅓ *s*(11.3.0), 11½ *s*(11.2.0).

Clinodomes: *k*(011), 2 *k*(021), ½ *l*(012).

Pyramids: —2 *q*(121), —*p*(111), +2 *q*(12$\bar{1}$), +*p*(11$\bar{1}$), +*w*(21$\bar{1}$), —4 *x*(342), —2 *x*(322), +2 *x*(32$\bar{2}$), —4 *n* (142), —2 *n*(122), +4 *n*(14$\bar{2}$), +2 *n*(12$\bar{2}$), —2 *y*(522), +2 *y*(52$\bar{2}$), +*Z*(311), —*w*(411), —3 *W*(10.3.3), —3 *V* (16.3.3), +4 *m*(14$\bar{4}$), —10 *T*(4.10.5).

Bavenite.

Monoclinic.

E. Artini. Rend. Acad. Linc., 1901, 10, 139.

Pinacoid: *a*(100).

Prisms: *m*(110), *g*(210).

Domes: (103), (101).

Beckelite.

Isometric.

J. Morozewicz. Min. Mitth., 1905, *24*, 120.

Cube: *a*(100).

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Octahedron: $o(111)$.
Dodecahedron: $d(110)$.

BENITOITE.

Hexagonal, ditrigonal-bipyramidal.

G. D. Lauderback. Univ. Calif. Pub. (Geol.), 1907, *5*, 149.
Base: $c(0001)$.
Prisms: $m(10\bar{1}0)$, $\mu(01\bar{1}0)$.
Trigonal pyramids: $p(10\bar{1}1)$, $\pi(0111)$.

A. F. Rogers. Science, 1908, *28*, 616.
Trigonal pyramid: $e(01\bar{1}2)$.

C. Palache. Am. Jour. Sci., 1909, *27*, 398.
Prism: $a(11\bar{2}0)$.
Pyramid: $x(22\bar{4}1)$.

BERTRANDITE.

S. L. Penfield. Am. Jour. Sci., 1897, *4*, 316.
Prism: $f(130)$.
Domes: $e(031)$, $k(0.12.1)$.

O. C. Farrington and E. W. Tillotson. Field Col. Mus. Geol. Ser., 1908, *3*, 136.
Dome: $l(203)$.

BERYL.

P. Jeremejew. Vh. Min. Ges., 1892, *29*, 230, and 1895, *33*, 26.
Prism: $(13.1.\bar{14}.0)$.
Pyramids: $v(4045)$, $\mu(11\bar{2}6)$, $(19.1.\bar{2}0.1)$.

W. E. Hidden and H. S. Washington. Am. Jour. Sci., 1887, *33*, 501.
Pyramids: $\psi(1.0.\bar{1}.12)$, $\phi(8.7.\bar{15}.6)$, $x(8.7.\bar{15}.7)$, $\Psi(9.7.\bar{16}.8)$.

C. Vrba. Zeitschr. f. Kryst., 1894, *24*, 104.
Pyramids: $\epsilon(60\bar{6}5)$, $\xi(11\bar{2}4)$, $\lambda(15.1.\bar{16}.1)$.

G. d'Archardi. Soc. Tosc. d. sc. nat. Pisa, 1904.
Pyramid: $(11.2.\bar{13}.3)$.

BISMITE.

(Shown to be hexagonal-rhombohedral by W. T. Schaller.)

W. T. Schaller. Dana's System, Appen. II., 1909, 16.
Base: $c(0001)$.
Rhombohedrons: $o(10\bar{1}6)$, $q(10\bar{1}5)$, $u(10\bar{1}4)$, $k(10\bar{1}3)$, $(20\bar{2}5)$?, $(10\bar{1}2)$?

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BIXBYITE.

Isometric.

S. L. Penfield and H. W. Foote. Am. Jour. Sci., 189
Cube: $a(100)$.
Trapezohedron: $n(211)$.

BLOMSTRANDINE–PRIORITE.

Orthorhombic.

W. C. Brögger. Min. d. Südnorw. Gran.-peg., 1906, 9
Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prisms: $m(110)$, $r(120)$, $n(130)$, $t(140)$.
Domes: $x(021)$, $d(101)$.
Pyramids: $p(111)$, $\pi(121)$.

BOOTHITE.

Monoclinic.

W. T. Schaller. Univ. Calif. Pub. (Geol.), 1903, *3*,
Pinacoids: $a(100)$, $c(001)$.
Prism: $m(110)$.
Domes: $t(\bar{1}01)$, $z(\bar{3}01)$.
Pyramids: $\pi(\bar{1}12)$, $e(\bar{1}11)$, $\sigma(\bar{1}21)$.

BOTRYOGEN.

A. S. Eakle. Univ. Calif. Pub. (Geol.), 1903, *3*, 23.
Pinacoid: $a(100)$.
Prism: $t(450)$.
Domes: $d(\bar{4}03)$, $v(023)$, $o(043)$.
Pyramids: $p(\bar{2}23)$, $s(\bar{2}43)$.

BOULANGERITE.

Orthorhombic.

Hj. Sjögren. Geol. Fören. Förh., 1897, *19*, 153.
Pinacoids: $a(100)$, $b(010)$.
Prisms: $r(210)$, $q(320)$, $m(110)$, $n(120)$, $\mu($
$k(180)$, $i(1.10.0)$, $h(1.14.0)$.
Dome: $w(012)$.

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Bournonite.

F. Gonnard. Bull. soc. fr. min., 1897, *20*, 312, and 1907, *30*, 62.
Prisms: (18.5.0), (19.5.0).
Pyramids: (5.7.12), (50.66.59), (198).

P. Termier. Bull. soc. fr. min., 1897, *20*, 101.
Prisms: (950), (780), (380).
Pyramids: (568), (11.3.4).

A. Schmidt. Zeitschr. f. Kryst., 1892, *20*, 151.
Prism: C(530).

B. Mauritz. Ann. Mus. Nat. Hung., 1905, *3*, 461.
Dome: g(601).

Braunite.

R. Koechlin. Min. Mitth., 1908, *27*, 266.
Dome: r(013).
Pyramids: z(353), f(121), v(122), w(344), g(153).

G. Flink. Bihang. K. K. Sven. Vet. Ak., *16* (2).
Domes: (401), (304).
Pyramids: (212), (645), (524).

Britholite.

Orthorhombic.

C. Winther. Medd. om Grönland, 1901, *24*, 190.
Pinacoid: b(010).
Prisms: m(110), z(130).
Dome: d(021).
Pyramid: p(111).

Brookite.

E. S. Dana. Am. Jour. Sci., 1886, *33*, 314.
Prisms: ϕ(120).

E. Hussak. Min. Mitth., 1892, *12*, 460.
Dome: g(305).
Pyramids: v(124), ξ(146).

C. Palache. Festschr. 70th Gebrust. Rosenbush, 1906, 311.
Pyramids: G(9.10.9), E(544), F(534).

L. Brugnatelli. Rend. R. Inst. Lomb., 1899, *32*, 1405.
Pyramid: σ(324).

H. Busz. Neues Jahrb. Min., 1901, *2*, 135.
Pyramid: ϑ'(5.13.17).

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H. H. Robinson. Am. Jour. Sci., 1901, *12*, 182.
Pyramid: $\beta(5.4.10)$.

CALAVERITE.

Monoclinic.

S. L. Penfield and W. E. Ford. Am. Jour. Sci., 1901,
Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prism: $m(110)$.
Orthodomes: $I(2.0.11)$, $H(5.0.11)$, $D(304)$, $F(11.0.5)$, $E(10.0.4)$, $C_1(401)$, $C(501)$, $B(801)$, $B_1(17.0.2)$, $B_2(901)$, $L(\bar{1}04)$, $M(\bar{1}01)$, $M_2(\bar{1}\bar{1}.0.10)$, $N_1(11.0.6)$, $N(\bar{2}01)$, $P(\bar{1}\bar{1}.0.2)$, $P_1(\bar{2}5.0.4)$, $R(\bar{9}01)$, $R_1(\bar{1}\bar{1}.0.1)$, $R_2($
Pyramids: $e(441)$ or $(42.44.11)$, $p(111)$, $f(11\bar{2}$ $\mu(17.40.2)$ or $(33.80.4)$, $t(13.20.4)$, $g(11.29.5)$, $\omega(20.15.12)$, $o(13.22.10)$, $n(11.14.10)$, $i(10.7.1$ $27)$, $g_1(10.15.22)$, $g(4.7.10)$, $y(296)$, $v(2.11.1$ $21)$, $r(10.44.15)$, $u(\bar{1}\bar{1}.18.10)$, $j(\bar{7}56)$, $x(11.20.$ $6)$, $s_1(\bar{2}.11.1)$?, $\sigma(\bar{2}.10.1)$?, $\tau(31.38.11)$, $z(\bar{1}5.$ $21.2)$.

CALCITE.

Schnorr. Wissen. Beil. z. Programm d. Realgym. 1896, 16.
Prism: $\psi(10.1.\bar{1}\bar{1}.0)$.
Scalenohedrons: $(21.5.\bar{2}6.16)$, $(11.5.\bar{1}6.6)$, $(12.68.\bar{8}0.35)$, $(4.9.\bar{1}3.6)$, $(15.7.\bar{2}\bar{2}.8)$.

H. P. Whitlock. Ann. Rep. N. Y. State Mus., 1908, 2
Prism: $\sigma(7\bar{1}80)$.
Scalenohedron: $\mathfrak{s}:(17.13.\bar{3}0.4)$, $\mathfrak{t}(3.13.\bar{1}\bar{6}.8)$.

H. P. Whitlock. N. Y. State Mus. Mem., 13, 1910.
Prism: $\mu(5\bar{3}80)$.
Pyramid: $\phi(8.8.\bar{1}6.1)$.
Rhombohedron: $Q\cdot(07\bar{7}1)$.
Scalenohedrons: $\mathfrak{t}$ $(8.14.22.3)$, $\mathfrak{f}$: $(4.6.10.1)$, $\mathfrak{N}$ $\mathfrak{l}$: $(39.15.\bar{5}4.8)$, $\mathfrak{e}(1.11.\bar{1}\bar{2}.2)$, $\mathfrak{r}(3.15.\bar{1}\bar{8}.2)$, $\mathfrak{H}(9$

W. T. Schaller. Zeitschr. f. Kryst., 1908, *44*, 321.
Prism: $j(7.6.\bar{1}3.0)$.

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Rhombohedron: $o(0.14.\bar{1}4.17)$.

Scalenohedrons: $\mathfrak{k}(1.6.7.13)$, $\mathfrak{h}(11.5.\bar{1}6.21)$, $O(8.2.\bar{1}0.3)$, $\mathfrak{l}(3.10.\bar{1}3.3)$.

C. Palache. Geol. Surv. Mich., 1900, *6*, 161.

Pyramids: $\nu(11\bar{2}1)$, $\omega(16.16.32.9)$.

Rhombohedrons: $R\cdot(20\bar{2}1)$.

Scalenohedrons: $u:(3.5.\bar{8}.13)$, $P(17.11.28.6)$, $U(10.4.14.3)$, $\Pi:(10.1.1\bar{1}.3)$, $\Gamma:(17.1.\bar{1}8.4)$, $\Delta:(13.1.\bar{1}4.3)$, $\Sigma\cdot(22.2.24.5)$, $\Theta:(40.4.\bar{4}4.9)$, $\Phi:(9.1.\bar{1}0.2)$, $\Lambda:(32.4.36.7)$, $F(5.11.\bar{1}6.6)$, $\mathfrak{w}:(7.4.\bar{1}1.6)$, $\mathfrak{b}(20.11.31.15)$, $N(12.4.16.11)$, $M(8.4.\bar{1}2.5)$, $Z(16.4.20.5)$, $\mathfrak{a}(37.19.56.21)$, $P(13.7.\bar{2}0.3)$, $E(32.56.88.69)$*, $I(17.38.55.24)$, $\mathfrak{b}(4.36.\bar{4}0.31)$, $\mathfrak{f}(6.20.\bar{2}6.13)$, $A(6.14.20.7)$, $K(1.11.\bar{1}2.8)$, $D(3.8.11.4)$, $I(7.17.24.8)$, $B(12.40.\bar{5}2.11)$.

A. F. Rogers. School of Mines Quar., 1901, *22*, 42, and 1902, *23*, 336.

Pyramid: $\chi(5.5.10.1)$.

Rhombohedrons: $H:(0.18.\bar{1}8.13)$, $J\cdot(0.13.\bar{1}3.4)$.

Scalenohedron: $\lambda:(17.5.\bar{2}2.12)$.

W. H. Hobbs. Univ. Wis. Sci. Ser. Bull., 1895, *1*, 115.

Rhombohedrons: $\mathfrak{c}(24.0.\bar{2}4.1)$, $\mathfrak{a}(0.11.\bar{1}1.20)$, $\mathfrak{b}(0.18.18.25)$.

F. Sansoni. Giorn. d. Min., 1890, *1* (2), 129, and 1894, *5*, 72.

Rhombohedrons: $Z\cdot(22.0.22.1)$, $(20.0.\bar{2}0.1)$, $(0.11.\bar{1}1.4)$.

Scalenohedrons: $(41.21.62.20)$, $(25.13.38.12)$, $(21.19.40.2)$. $(4.20.24.17)$, $(10.3.\bar{1}3.2)$, $(15.4.19.3)$, $(1.13.\bar{1}4.1)$.

G. Thürling. Neues Jahrb. f. Min. B.-B., 1886, *4*, 327.

Rhombohedrons: $(11.0.11.1)$, (0553), (0774), $(0.11.\bar{1}1.6)$, $(0.28.\bar{2}8.1)$.

Scalenohedrons: $(13.3.\bar{1}6.10)$, $(22.8.\bar{3}0.37)$, $(3.11.\bar{1}4.7)$.

G. Cesàro. Ann. Soc. Géol. Belg., 1889, *16*, 165.

Rhombohedrons: (8081), $(0.19.19.20)$, $(0.17.17.16)$.

Scalenohedrons: $(19.10.2\bar{9}.6)$, $(2.11.\bar{1}3.6)$, $(4.12.\bar{1}6.7)$, $(14.2.\bar{1}6.3)$, $(15.7.\bar{2}2.2)$, $(17.9.\bar{2}6.2)$, $(17.8.\bar{2}5.3)$, $(2.20.\bar{2}2.21)$, $(3.61.\bar{6}4.26)$.

H. Höfer. Min. Mitth., 1891, *12*, 487.

* Substituted by Palache for (21·35·56·44) given in paper cited.

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Rhombohedrons: (13.0.$\bar{1}$3.2), (0.13.$\bar{1}\bar{3}$.1).
Scalenohedrons: (5.17.$\bar{2}\bar{2}$.2).

D. B. Sterrett. Am. Jour. Sci., 1904, *18*, 73.
Rhombohedron: *l*(40$\bar{4}$5).

K. Johansson. Geol. Fören. Förh., 1892, *14*, 49.
Rhombohedrons: (0.14.$\bar{1}$4.11), (0.36.$\bar{3}$6.1).
Scalenohedrons: (7.6.13.2), (16.10.26.5).

H. P. Whitlock. Zeitschr. f. Kryst., 1907, *43*, 321.
Rhombohedron: Y·(0.19.$\bar{1}$9.13).
Scalenohedron: 𝔘(14.12.$\bar{2}$6.5).

G. Flink. Medd. om Grönland, 1899, 24.
Rhombohedron: (0885).
Scalenohedron: (35$\bar{8}$2).

G. Melczer. Föld. Közlöny, 1896, 26, 79.
Rhombohedrons: g(0.16.16.5), (0.12.12.1).
Scalenohedrons: e(9.2.11.13), a(1.10.1$\bar{1}$.6), (4.20.24.11), (52$\bar{7}$1), (63.28.91.11), (27$\bar{9}$1), (3.16.19.2).

O. C. Farrington. Field Col. Mus. Pub. (Geol.), 1900, No. 7.
Rhombohedron: (0.20.20.1).

C. Bumüller. Neues Jahrb. f. Min., B.-B., 1909, *28*, 233.
Rhombohedrons: (0.29.29.4), (0.10.10.1), (0.18.18.1).
Scalenohedrons: (18.12.$\bar{3}$0.5), (25.20.$\bar{4}$5.3), (8.36.44.11), (15.25.40.1).

G. Moesz. Föld. Közlöny, 1897, *27*, 495.
Scalenohedrons: (14$\bar{5}$9), (4.7.11.18), (5.4.$\bar{9}$.13), (52$\bar{7}$6), (10.7.$\bar{1}$7.9).

F. Gonnard. Bull. soc. f. min., 1897, *20*, 18.
Scalenohedrons: (7.3.10.13), (11.6.$\bar{1}$7.23), (1783), (19.36.$\bar{5}\bar{5}$.13), (4.7.1$\bar{1}$.3), (9.23.$\bar{3}$2.10), (16.59.$\bar{7}\bar{5}$.17).

C. Morton. Ofvers. Vet. Akad. Stockh., 1884, *8*, 65.
Scalenohedrons: (3257), (3.24.27.7).

G. Cesàro. Mem. cor. Acad. roy. Belg., 1886, 38.
Scalenohedrons: (11.3.$\bar{1}$4.8).

G. d'Achiardi. Att. Soc. Tosc., 1897, *20*, 49.
Scalenohedrons: (7.3.10.4), (10.9.$\bar{1}$9.1).

F. Sansoni. Att. Soc. Torino, 1888, *23*.
Scalenohedron: (19.11.$\bar{3}$0.8).

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F. Stöber. Abhandl. z. geol. Spec. Karte Els.-Loth., 1892, *5*, 1.
Scalenohedron: $(15.13.\bar{2}8.2)$.

H. P. Whitlock. Am. Jour. Sci., 1907, *24*, 426.
Scalenohedrons: H $(6\bar{3}95)$, $C(1.13.\bar{1}4.10)$.

F. Sansoni. Bull. Ac. Belg., 1885 (3), *9*, 287.
Scalenohedron: $(10.5.\bar{1}5.4)$.

O. C. Farrington and E. W. Tillotson. Field Col. Mus. (Geol.), 1908, *3*, 140.
Scalenohedrons: v:$(11.4.\bar{1}5.3)$, μ:$(20.11.\bar{3}1.11)$.

A. S. Eakle. Univ. Cal. Bull. (Geol.), 1907, *5*, 91.
Scalenohedron: X $(16.7.\bar{2}3.3)$.

J. Beykirch. Centralbl. f. Min., 1901, *2*, 494.
Scalenohedron: $(25.7.\bar{3}2.5)$.

H. Buttgenbach. Soc. Geol. Belg. Ann., 1905, *32*, 86.
Scalenohedron: $(61\bar{7}1)$.

L. V. Pirsson. Am. Jour. Sci., 1891, *41*, 61.
Scalenohedron: $J(8.20.\bar{2}8.9)$.

H. P. Whitlock. School of Mines Quar., 1910, *31*, 231.
Scalenohedrons: $\mathfrak{T}(6.13.\bar{1}9.4)$, $\mathfrak{D}(21.5.\bar{2}6.18)$.

Calomel.

K. Vrba. Zeitschr. f. Kryst., 1889, *15*, 449.
Prism: $g(610)$.

V. Goldschmidt and B. Mauritz. Zeitschr. f. Kryst., 1908, *44*, 393.
Prism: $l(120)$.
Second Order Pyramids: $\delta(016)$, $d(031)$.

W. F. Hillebrand and W. T. Schaller. U. S. Geol. Surv. Bull., 405, 1909, 157.
Second Order Pyramids: $j(0.1.12)$, $Y(018)$, $\Phi(035)$.
First Order Pyramids: $H(1.1.24)$, $\epsilon(117)$, $T(334)$, $K(553)$.
Ditetragonal Pyramids: $S(3.4.10)$.

Carnallite.

C. Busz. Ber. Med.-naturwiss. Ges. Münster, 1906.
Prism: $x(120)$.
Domes: $r(083)$, $q(071)$.
Pyramids: $\iota(332)$, $y(131)$.

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H. Bücking. Ber. Ak. Berlin, 1901, 539.
Domes: $n(103)$, $g(012)$, $h(032)$.
Pyramids: $u(118)$, $t(114)$, $w(126)$, $v(136)$.

Cassiterite.

Kohlmann. Zeitschr. f. Kryst., 1895, *24*, 350.
Prism: $\lambda(10.9.0)$.
Ditetragonal Pyramid: $f(835)$.

L. H. Borgström. Zeitschr. f. Kryst., 1904, *40*, 1.
Ditetragonal Pyramids: $H(8.13.4)$, $K(6.10.3$
$M(8.15.4)$, $N(241)$, $O(492)$, $R(13.17.6)$,
$w(16.19.7)$, $T(783)$.

Celestite.

E. Artini. Rend. d. R. Inst. Lomb., 1893, (2), *26*, 3
Prisms: (450), (230).
Dome: (087)?
Pyramids: (326), (562).

L. Buchrucker. Zeitschr. f. Kryst., 1891, *19*, 113.
Domes: $\xi^2(0.1.20)$, $\xi'(0.1.10)$.
Pyramid: $\pi'(214)$.

F. Zambonini. Rend. Acc. Lincei, 1904, *13*, (1), 37.
Dome: (017).

E. Billows. Riv. Min. Ital., 1904, *31*, 3.
Domes: (0.1.16), (105).
Pyramids: (119), (117).

E. Manasse. Atti. Soc. Tosc., 1907, *23*.
Dome: (019).
Pyramid: (327).

A. Arzruni and K. Thaddéeff. Zeitschr. f. Kryst., 1
Dome: $N(705)$.
Pyramids: $Q(332)$, $R(1.19.19)$.

F. Millosevich. Rend. Acc. Lincei Sc., *8*.
Pyramid: (322).

F. Stöber. Zeitschr. f. Kryst., 1893, *21*, 339.
Pyramid: (1.10.10).

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CELSIAN.

Monoclinic.

J. E. Strandmark. Geol. Fören. Förh., 1903, *25*, 289.
Pinacoids: $P(001)$, $M(010)$.
Prism: $K(110)$.
Dome: $Y(\bar{2}01)$.
Pyramids: $(\bar{1}14)$, $G(\bar{1}12)$, $o(\bar{1}11)$, $(\bar{3}31)$, $(\bar{3}11)$.

CENOSITE.

Orthorhombic.

Hj. Sjögren. Geol. Fören. Förh., 1897, *19*, 54.
Pinacoids: $b(010)$, $c(001)$.
Prisms: $m(110)$, $h(230)$.
Domes: $g(201)$, $f(023)$, $d(011)$, $e(021)$.

CERUSSITE.

H. Traube. Zeitschr. Geol. Ges., 1894, *46*, 60.
Prism: f(170).
Dome: e(025).
Pyramids: g(171), a(441).
H. Buttgenbach. Soc. géol. Belg. Ann., 1902, *29*, 103.
Prisms: (150), (310).
E. Artini. Rend. Acc. Lincei, *5*, (4), 20.
Domes: $R(052)$, $E(104)$.
Pyramid: $H(161)$.
W. H. Hobbs. Am. Jour. Sci., 1895, *50*, 121.
Prism: b(380).
E. Artini. Riv. Min. Ital., 1896, *16*, 21.
Dome: (0.13.1).
H. L. Barviř. Ber. böhm. Ges. Wiss., 1900, *36*.
Domes: (0.22.1), (0.29.1), (0.33.1), (0.37.1).
P. F. Hubrecht. Zeitschr. f. Kryst., 1905, *40*, 147.
Domes: $Q(054)$, $T(034)$.
V. Goldschmidt. Neues Jahrb. f. Min. B.-B., 1902, *15*, 562.
Dome: $A(304)$.
Löw. Földt. Közlöny, 1908, *38*, 205.
Domes: $M(0.13.2)$, $D(0.11.2)$, $C(072)$, $B(092)$.

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CHALCANTHITE.

W. T. Schaller. Bull. Univ. Calif. (Geol.), 1903, *3*, 212.
Prism: $l(120)$.
Pyramid: $g(1\bar{4}1)$.

CHALCOCITE.

G. Boeris. Zeitschr. f. Kryst., 1894, *23*, 235.
Dome: (052).

CHALCOPYRITE.

K. Zimànyi. Zeitschr. f. Kryst., 1896, *27*, 95.
Pyramids: $\chi(704)$, $\zeta(907)$, $\tau(605)$.

O. Luedecke. Min. d. Harzes, 1896, 113.
Pyramids: $q(503)$, $Q(504)$, $i(706)$, $H'(203)$.
Sphenoids: $t(221)$, $r(332)$.
Scalenohedron: $y(313)$.

Z. Toborffy. Zeitschr. f. Kryst., 1904, *39*, 366.
Pyramid: $\tau(509)$.
Sphenoid: $\eta(771)$.

B. Mauritz. Zeitschr. f. Kryst., 1905, *40*, 589.
Pyramids: $T(601)$, $W(701)$, $K(11.0.9)$, $M(14.0.11)$, $\pi(403)$, $\epsilon(705)$, $\delta(10.0.7)$, $L(23.0.12)$, $R(703)$, $S(502)$.
Sphenoid: $d_1(1\bar{1}4)$.
Scalenohedrons: $s(511)$, $N(9.\bar{1}.12)$, $H(8.\bar{1}.10)$, $Z(525)$, $F(4\bar{1}4)$, $G(10.4.7)$.

Ungemach. Bull. soc. f. min., 1906, *29*, 194.
Pyramid: (11.0.3).
Sphenoid: (558).

J. Beckenkamp. Zeitschr. f. Kryst., 1907, *43*, 43.
Pyramid: $\mu(205)$.

W. J. Lewis and Hall. Min. Mag., 1900, *12*, 324.
Sphenoids: $\sigma(1.1.12)$?, $\beta(118)$, $\lambda(229)$, $\rho(553)$, $f(552)$, $F(551)$.

H. Buttgenbach. Soc. géol. Belg. Ann., 1898, 25.
Sphenoid: $\gamma(115)$.

S. L. Penfield. Am. Jour. Sci., 1890, *40*, 207.
Sphenoid: $\phi(772)$?
Scalenohedrons: $\chi(122)$, $\omega(576)$.

L. Colomba. Rend. Acc. Lincei, 1905, *15* (5).
Sphenoid: $\mu(11.11.1)$.
Scalenohedron: $Y(515)$.

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G. Cesàro. Bull. Ac. Belg., 1894, *28*, 182.
Scalenohedron: $s(525)$.
Sonheur. Zeitschr. f. Kryst., 1894, *23*, 545.
Scalenohedrons: $f(312)$, (534).

Chalcostibite.

C. Friedel.* Bull. Soc. f. Min., 1879, *2*, 203.
Pinacoids: $c(001)$, $b(010)$.
Domes: $g(201)$, $i(302)$, $d(101)$, $h(203)$, $u(061)$, $t(021)$.
H. Laspeyres. Zeitschr. f. Kryst., 1891, *19*, 428.
Domes: $e(307)$, $f(011)$.
Pyramids: $q(863)$, $p(6.12.7)$, $r(134)$.
S. L. Penfield and A. Frenzel. Am. Jour. Sci., 1897, *4*, 27.
Prism: $l(130)$.
Domes: $\Delta(209)$, $\Delta_1(207)$, $\Delta_2(103)$, $\Delta_3(205)$, $j(102)$, $h(203)$, $s(065)$.
Pyramids: $\mu(136)$, $\nu(133)$, $\pi(265)$, $\rho(263)$, $\sigma(4.12.5)$, $\tau(261)$.
L. J. Spencer. London Min. Soc., April 14, 1896.
Pyramids: $\alpha(233)$, $\beta(354)$, $\gamma(474)$, $\delta(475)$, $\epsilon(476)$.

Chalmersite.

Orthorhombic.

C. Palache. Am. Jour. Sci., 1907, *24*, 255.
Pinacoids: $c(001)$, $b(010)$, $a(100)$.
Prisms: $m(110)$, $l(130)$.
Domes $f(012)$, $g(011)$, $d(021)$, $y(103)$.
Pyramids: $p(111)$, $o(236)$, $r(233)$, $s(263)$, $t(136)$, $u(1.9.12)$.

Clormanganokalite.

Hexagonal-rhombohedral.

H. J. Johnston-Lavis and L. J. Spencer. Min. Mag., 1908, *15*, 54.
Prism: $a(11\bar{2}0)$.
Rhombohedron: $r(10\bar{1}1)$.

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* Indices transposed to the position adopted by Laspeyres $a:b:c = 0.5283:1:0.6364$.

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CHRYSOBERYL.

G. Melczer. Zeitschr. f. Kryst., 1900, *33*, 240.
Prisms: $l(210)$, $q(140)$.
Pyramids: $f(10.1.10)$, $g(515)$, $h(313)$, $p(232)$.

V. Goldschmidt and H. Preiswerk. Zeitschr. f. Kryst., 1900, *33*, 240.
Prism: $h(150)$.
Pyramids: $l(133)$, $a(311)$, $\beta(511)$, $Q(142)$.

A. Liffa. Zeitschr. f. Kryst., 1902, *36*, 606.
Pyramids: $\pi(131)$, $\tau(277)$, $\psi(11.20.20)$, $\phi(1.18.9)$, $w(7.10.8)$.

CHRYSOLITE.

F. Zambonini. Zeitschr. f. Kryst., 1899, *32*, 152.
Prism: $t(230)$.
Pyramid: $u(141)$.

CINNABAR.

K. Zimányi. Zeitschr. f. Kryst., 1906, *41*, 439.
Pyramid: $I(11\bar{2}2)$.
Rhombohedrons: $j(50\bar{5}8)$, $A(80\bar{8}9)$, $X(90\bar{9}8)$, $V(80\bar{8}5)$, $Y(11.0.11.4)$.

CLAUDETITE.

A. Schmidt. Zeitschr. f. Kryst., 1888, *14*, 573.
Prisms: $r(120)$, $s(130)$, $t(1.10.0)$.

CLINOHEDRITE.

Monoclinc-clinohedral.

S. L. Penfield and H. W. Foote. Am. Jour. Sci., 1898, *5*, 289.
Pinacoid: $b(010)$.
Prisms: $h(320)$, $m(110)$, $m_1(\bar{1}10)$, $n(120)$, $l(130)$.
Domes: $e(101)$, $e_1(\bar{1}0\bar{1})$.
Pyramids: $p(111)$, $p_1(11\bar{1})$, $q(\bar{1}11)$, $q_1(\bar{1}1\bar{1})$, $r(\bar{3}31)$, $s(\bar{5}51)$, $t(\bar{7}71)$, $u(\bar{5}31)$, $o(131)$, $o_1(13\bar{1})$, $x(\bar{1}3\bar{1})$, $y(\bar{1}2\bar{1})$.

COLEMANITE.

A. S. Eakle. Bull. Univ. Calif. (Geol.), 1902, *3*, 31.
Prism: $l(310)$.
Domes: $\rho(301)$, $g(\bar{5}02)$, $f(801)$.

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Pyramids: $\eta(232)$, $\phi(522)$, $p(142)$, $n(141)$, $u(164)$, $\mu(165)$, $P(\bar{1}23)$, $w(182)$, $s(\bar{3}41)$.

Cordylite.

Hexagonal.

G. Flink. Medd. om Grönland, 1898, *14*, 236.
Base: $c(0001)$.
Prism: $m(10\bar{1}0)$.
Pyramids: $q(10\bar{1}3)$, $p(4.0.\bar{4}.15)$, $r(20\bar{2}3)$, $s(40\bar{4}3)$.

Corundum.

G. Melczer. Zeitschr. f. Kryst., 1902, *35*, 561.
Prism: $(52\bar{7}0)$.
Pyramids: $(5.5.\bar{1}0.7)$, $(5.5.\bar{1}0.3)$, $(7.7.\bar{1}4.2)$, $(11.11.\bar{2}2.2)$.
Rhombohedrons: $(60\bar{6}5)$, $(70\bar{7}8)$, $(40\bar{4}5)$, $1.0.\bar{1}.10)$.

H. L. Bowmann. Min. Mag., 1900, *12*, 349.
Pyramids: $\tau(11.11.\bar{2}2.9)$, $\sigma(8.8.\bar{1}6.5)$, $\pi(13.13.\bar{2}6.6)$, $\xi(5.5.\bar{1}0.2)$, $u(33\bar{6}1)$, $\epsilon(11.11.\bar{2}2.3)$.

R. Busz. Zeitschr. f. Kryst., 1889, *15*, 616.
Pyramid: $(11.11.\bar{2}2.6)$.

A. Nies and V. Goldschmidt. Neues Jahrb. f. Min., 1908, *2*, 97.
Pyramids: $p(5.5.\bar{1}0.1)$, $p_1(10.5.\bar{5}.1)$.
Rhombohedrons: $\theta(80\bar{8}1)$, $x(50\bar{5}1)$.
Scalenohedrons: $\iota(21\bar{3}1)$, $\phi(41\bar{5}1)$, $\phi_1(14\bar{5}1)$, $\chi(2.8.\bar{1}0.1)$.

M. Bauer. Neues Jahrb. f. Min., 1896, *2*, 197.
Rhombohedron: $\tau(01\bar{1}2)$.

Crocoite.

C. Palache. Am. Jour. Sci., 1896, *1*, 389.
Prisms: $S(10.3.0)$, $T(530)$.

F. Slavik. Zeitschr. f. Kryst., 1904, *39*, 302.
Prism: $f_1(470)$.

K. Redlich. Zeitschr. f. Kryst., 1896, *28*, 607.
Dome: (403).

G. Moesz. Zeitschr. f. Kryst., 1899, *34*, 707.
Dome: $x(\bar{3}01)$.
Pyramid: $\Theta(331)$.

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CUPRITE.

H. A. Miers. Min. Mag., 1889, 8, 204.
Trapezohedron: (533).

DANBURITE.

M. Weber. Zeitschr. f. Kryst,. 1903, *38*, 620.
Domes: (0.22.5), (0.31.5), (0.23.1), (0.29.1), (0.50.1), (16.0.1).
Pyramids: (10.38.19), $\eta(261)$, $\epsilon(223)$, $\gamma(4.1.10)$, $\theta(5.36.8)$.

DATOLITE.

E. H. Kraus and C. W. Cook. Am. Jour. Sci., 1906, *22*, 21.
Domes: $n_2(0.1.10)$, $m_y(067)$.
Pyramid: $m_2(\bar{1}.1.10)$.
O. C. Farrington. Am. Jour. Sci., 1898, *5*, 285.
Dome: $\mathfrak{A}(\bar{3}02)$.
A. Osann. Zeitschr. f. Kryst., 1895, *24*, 543.
Pyramids: $\mathfrak{E}(445)$, $\mathfrak{G}(\bar{3}.14.14)$, $\mathfrak{B}(124)$.
F. Slavik and Fišer. Centralbl. Min., 1903, 229.
Pyramid: $\mu_1(\bar{7}44)$.
H. P. Whitlock. N. Y. State Mus. Bull., 98, 1905, 19.
Pyramids: $\epsilon'(\bar{1}48)$, $\lambda'(\bar{1}49)$, $\mu'(\bar{1}.4.10)$.
H. P. Whitlock. School of Mines Quar., 1910, *31*,225.
Pyramids: $k(132)$, $Y(255)$.

DELORENZITE.

Orthorhombic.

F. Zambonini. Zeitschr. f. Kryst., 1908, *45*, 76.
Pinacoids: $a(100)$, $b(010)$.
Prisms: $m(110)$, $g(130)$?
Dome: $d(201)$.
Pyramid: $s(111)$.

DESCLOIZITE.

L. J. Spencer. Min. Mag., 1908, *15*, 31.
Prism: (310).

DIAMOND.

P. Jeremejew. Verh. russ. min. Ges., 1896, *34*, and 1899, *36*.
Tetragonal Tristetrahedrons: (552), (772).
Hexakistetrahedrons: (971), (432), (64.63.1).

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DIETZEITE.

Monoclinic.

A. Osann. Zeitschr. f. Kryst., 1894, *23*, 588.

Pinacoids: $a(100)$, $b(010)$, $c(001)$.
Prisms: $l(210)$, $m(110)$.
Dome: $r(\bar{1}01)$.
Pyramids: $s(\bar{2}23)$, $o(\bar{2}21)$.

DIASPORE.

G. Flink. Bull. Geol. Inst. Upsala, 1898, *4*, 63.

Dome: $d(031)$.

DOLEROPHANITE.

J. E. Standmark. Geol. Fören. Förh., 1902, *36*, 456.

Dome: (701).

DOLOMITE.

F. Becke. Min. Mitth., 1890, *11*, 536.

Scalenohedrons: $F(4153)$, $\Gamma(4.12.\bar{1}6.1)$.

DUFRENOYSITE.

Monoclinic.

R. H. Solly. Min. Mag., 1903, *13*, 151.

Prisms: $14r(1.14.0)$, $5r(150)$, $\frac{7}{2}r(270)$, $3r(130)$, $\frac{5}{2}r(250)$, $\frac{9}{4}r(490)$, $2r(120)$, $\frac{9}{5}r(590)$, $\frac{7}{4}r(470)$, $\frac{5}{3}r(350)$, $\frac{8}{5}r(580)$, $\frac{3}{2}r(230)$, $\frac{7}{5}r(570)$, $\frac{4}{3}r(340)$, $\frac{5}{4}r(450)$, $\frac{6}{5}r(560)$, $\frac{7}{6}r(670)$, $\frac{12}{11}r(11.12.0)$, $\frac{12}{11}s(12.11.0)$, $\frac{7}{6}s(760)$, $\frac{4}{3}s(430)$, $\frac{5}{3}s(530)$, $2s(210)$, $3s(310)$, $4s(410)$, $6s(610)$, $14s(14.1.0)$.

Domes: $+h(101)$, $-\frac{5}{2}h(502)$, $-\frac{7}{4}h(704)$, $-\frac{3}{2}h(302)$, $-\frac{5}{4}h(504)$, $9k(091)$, $8k(081)$, $\frac{11}{2}k(0.11.2)$, $5k(051)$, $\frac{9}{2}k(092)$, $4k(041)$, $\frac{7}{2}k(072)$, $3k(031)$, $\frac{11}{4}k(0.11.4)$, $\frac{5}{2}k(052)$, $\frac{7}{3}k(073)$, $\frac{9}{4}k(094)$, $\frac{11}{5}k(0.11.5)$, $2k(021)$, $\frac{15}{8}k(0.15.8)$, $\frac{7}{4}k(074)$, $\frac{17}{10}k(0.17.10)$, $\frac{5}{3}k(053)$, $\frac{3}{2}k(032)$, $\frac{4}{3}k(043)$, $\frac{5}{4}k(054)$, $\frac{5}{6}l(056)$, $\frac{3}{4}l(034)$, $\frac{3}{5}l(034)$, $\frac{1}{4}l(014)$, $\frac{1}{5}l(015)$, $\frac{1}{6}l(016)$, $\frac{1}{9}l(019)$.

Pyramids: $-\frac{7}{2}q(272)$, $-\frac{5}{2}q(252)$, $-2q(121)$, $-\frac{3}{2}q(232)$, $+\frac{3}{2}q(23\bar{2})$, $+p(11\bar{1})$, $-2t(21\bar{2})$, $+2t(212)$, $+\frac{3}{4}t(343)$, $-4t(414)$, $+4t(41\bar{4})$, $-y(522)$, $-\frac{1}{2}y(512)$, $-3w(231)$,

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$+3w(23\bar{1})$, $-\frac{5}{2}u(452)$, $+\frac{5}{2}w(45\bar{2})$, $+2u(22\bar{1})$, $+\frac{3}{2}u(43\bar{2})$, $+u(211)$, $+\frac{1}{2}u(41\bar{2})$, $-3z(332)$, $-V(554)$, $-\frac{1}{2}V(524)$, $-8Z(784)$, $-9Y(593)$, $-4n(142)$.

Baumhauer. Zeitschr. f. Kryst., 1904, *24*, and 1907, *28*.

Domes: (207), (103), (205), (407), (047), (049), (025). (013), (027).

Pyramids: (223), (441).

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FORESTRY AND COLUMBIA.

By C. C. CURTIS.

In the popular mind forestry deals with the preservation and utilization of the timber lands of our country. In reality the primary object of the forest policy of the United States is the perpetuation of the country. No other enterprise is so intimately associated with its welfare and prosperity. Forestry stands as the foundation of the future growth and wealth of the nation.

Last summer the Connecticut steamboat line was obliged to discontinue its service at the upper stations of the river because of low water. Difficulties of this kind have frequently occurred before, but as yet there has resulted no concerted action in establishing a forest policy at all commensurate with the gravity of the situation. One of the foremost claims of forestry to public recognition and support is the fact that it means the conservation of the most important resource of the country, namely water. The floor of the forest is like a sponge, permitting the ready entrance of rains or the waters of melting snows. Thence the water gradually penetrates the deeper and more compact soil and is slowly doled out to feed the perennial springs which supply the rivulets and creeks and so make possible the streams for irrigation and the rivers for navigation. With the removal of the forest the texture of the soil becomes changed in a marked degree. This is due in part to the fact that under forest conditions the continued falling of the leaves and branches and of old trees constantly adds humus to the soil, increasing its lightness and porosity and power for holding water. In deforested districts so little is added to the soil in this way that it becomes firmer and less permeable. The drying out of exposed soils also changes their texture. When the forests are first removed the soils receive the moisture as under forest conditions, but in drying out they bake and a crust is formed which becomes firmer and harder with each wetting and drying. Soon a condition is reached when a large portion of the water runs off from the soil as from a roof and the subsoil no longer serves as a

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great reservoir to make possible the "perennial springs." So it comes about in many sections of the country that we have periodic complaints of low water and drought.

Directly related to this condition is another evil. In sections where the precipitation appears at certain seasons in the form of snow, this is sheltered by the forests and is gradually converted into water with the result that a larger portion settles into the soil. But when the water sheds have been stripped of their timber the snows quickly melt and periodic floods and erosion ensue. The same evils follow if the precipitation is in the form of heavy rains. The seriousness of these conditions cannot be estimated. We are constantly startled with the damage caused by floods, as recently in Paris. More destructive ones have occurred in this country and lesser ones are annual occurrences. But this loss is of little moment compared with erosion, which carries off the most fertile portion of the soil, filling up the channels of the streams, and compared with the dearth of water, the most essential factor in soil fertility and productiveness.

There is no question that the forests on the watersheds tend to conserve moisture and so regulate the water flow by making possible a greater absorption of the precipitation and that they retard the surface run off and check erosion.

Forestry not only maintains the most important natural resource of the country by making possible an adequate water supply; it also offers a substitute for another leading asset of the country. Our mineral resources can only be conserved; they will ultimately be exhausted. The power in our streams offers the only feasible substitute for coal that has as yet been suggested. It is altogether probable that the time will come when we will be obliged to utilize the power of the creeks and rivers for generating power as well as much of our light and heat.

The cause of forestry demands the support of every patriotic citizen because it makes possible favorable agricultural conditions. Every country, unless in humid climates, where the forest areas have been reduced below a certain percentage has conditions unfavorable to agriculture. Fertile regions in China, Spain, Italy and Turkey have become barren or of meager productivity through destruction of the forests. This remarks applies to nearly every

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country and even in the United States are regions that have materially declined for this reason. Drought, sudden and injurious climatic changes, late spring and early fall frosts and erosion follow in the track of excessive deforestation.

These facts are of first importance to the people of the United States. The prosperity of the country is due to the productivity of the farms. In the past they have yielded a surplus over consumption more than sufficient to meet the cost of our imports. During the past three or four years, however, the rate of consumption has increased much more rapidly than that of production and if this ratio continues we will be confronted in a few years with a situation where consumption equals production. In fact it has been estimated that by the middle of the next decade the United States will cease to export produce. Such a condition would be fatal and of course will not be realized, but people should understand that a forest policy must be inaugurated that will assist in improving the agricultural conditions and so make possible the future growth of the country.

What is the forestry situation in the United States? There are two important features to be considered in answering the question. From what has been said it is evident that not only must every acre of farm land produce more than at present but that every acre suitable for agricultural purposes must be so utilized in order to maintain the future prosperity of the country. In fifty years we shall have a population of one hundred and fifty million and Mr. Zon estimates that the forests will be reduced to one fourth the area of the country or 450 million acres and that one half of our area will be devoted to agriculture. Will this distribution of forests and farm land maintain a suitable balance in nature and secure favorable conditions for agriculture? It is impossible to answer this question definitely, but judging from the experience of other countries it would appear safe to assume that this relation will be a favorable one. Countries with 20 per cent. or less of their area in forests are subject to erosion, prolonged droughts and frosts. Turkey has 20 per cent. of her territory in forests, Spain 16 per cent., Italy 14 per cent., Greece 13 per cent., Portugal 3.5 per cent., and all of these countries suffer from unfavorable climatic conditions.

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Granting that the one fourth forested area of the country will be sufficient to maintain favorable agricultural conditions, the question naturally arises will this 450 million acres meet the demands of the country for timber? Statistics of European countries show that approximately one acre of timber land is required per capita. Apparently then our forest acreage would be ample for our needs, but we are no less extravagant in the use of timber than in other things. At the present time we are using six times as much timber per capita as in France and Germany and our forests are producing about one third as much per acre. Put in another way we could say that the consumption is three or four times greater than the increase or that each year's cut takes the growth of more than three years. It is evident that even the large extent of forest to-day, approximately 700 million acres, can not meet such a demand and also that we are consuming our reserve at a reckless rate, unparalleled in the history of any country. The hard wood supply is now nearing exhaustion, some kinds of wood are now practically out of the market and the stands of soft woods will not meet our requirements for more than twenty-five to thirty years. It is necessary not only to understand these facts but also to bear in mind that we must rely upon our own resources for timber. The world's demand for lumber is increasing at the rate of 5 per cent. annually. Europe has an annual deficit of 140 million cubic feet. The great lumber-producing countries of Sweden, Norway, Austria and Hungary are furnishing their maximum output. Russia will increase her export but little and Canada cannot meet the world's demand.

A wise forest plan is one of the most important and far reaching policies that state and nation can undertake. It affects every citizen and will decide whether the country is to be progressive and prosperous or backward and impoverished. Can we have sustained intelligent action in handling our natural resources, of which forestry is of fundamental importance, so that they may be controlled to meet the needs of the people? This is the question that to-day is testing the worth of our people and our form of government.

Such are some of the features of the forestry situation in this country, and there are some of our alumni who regret to see

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Columbia entering this field of work. The argument has actually been advanced that the field is too small. These people believe that the government will be the chief employer of our foresters and that the demand for them will soon be satisfied. It should be added that this argument, worthless as it is, is the best that can be offered. From what has been said it is evident that our forests must be under the control of the very best forestry methods. This means a very large number of trained men. Germany 150 years ago faced the same situation as we do to-day. Conditions became acute in 1800 and forced the government to adopt a settled forestry policy. Extensive forest reserves were established and the future cut was based upon the natural increment so that a sustained yield was ensured and there was no lessening of the wood capital of the country. Fernow states that in Saxony the cut increased 50 per cent. between 1820 and 1890 and thereafter at the rate of 5 per cent. annually up to 1904. In Prussia the increase was even greater. In 1830 the cut was 20 cu. ft. per acre; in 1865, 24 cu. ft.; in 1890, 52 cu. ft., and in 1904 it had grown to 65 cu. ft. Forest management had increased the yield more than three-fold in 75 years. A canvass in 1906 of the German forest covering an area of 15,600,000 acres showed a net annual yield of $2.40 per acre, practically representing a capital of $50 paying 5 per cent. interest. It is of interest to note that these results were obtained by utilizing non-agricultural lands, poor sandy soil, swamps, rough hills and forests as neglected as our own. This work has not been accomplished by a few men such as represent our forestry service to-day. The German government is deriving a very considerable part of her revenue from her forests, because she has an expert to care for each 9,600 acres of her forest lands. At this rate our national forest, amounting to approximately 190 million acres, would alone require 20,000 men as against a present force of about 2,000.

But the forest policy must apply to all timbered lands, three fourths of which are in private hands and these holdings contain the best stands, representing four fifths of all the wood. The annual yield of our forest averages less than 12 cu. ft. per acre, making a sorry comparison with the 40 cu. ft. in France, 50 cu. ft. in Switzerland, and 93 cu. ft. per acre in Saxony. Following the methods of these countries, upon which we can improve as well as

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profit from their mistakes, our forests can be brought up to the European standards of efficiency. Much of our territory is more favored by nature for forest growth than that of the continent, while many of our tree species are the finest in the world, as is evidenced by their extensive introduction into Germany and other countries. We can hardly be said to have a national forest policy. The small force of government officials are unable to give proper care to the national forests, while less than one per cent. of the private holdings are under any kind of forest administration. The neglect of the forests entails an average annual loss since 1870 of 50 million dollars and 50 lives through forest fires, while wasteful timbering operations cause the loss of from one third to one half of every tree that is felled.

It has often been stated that a forest policy can not be carried out by the private owner with profit owing to ill-devised taxation, cheap stumpage and fire risks. In many cases forests have been taxed out of existence. So long as timber lands are taxed on the basis of the annual crop the lumberman can not afford to hold young forest lands until the timber matures. The laws governing taxation will be modified because as at present they bring about clean cutting and consequent devastation and abandonment. Several states are considering or have introduced amendments to the laws to remedy this evil. Cheap stumpage has made a cheap product. Consequently the private owner could not afford to cut judiciously according to a wise forestry policy or go to any expense in perpetuating the forest supply. This drawback is rapidly disappearing in the waning of our virgin forest and the consequent steady rise in stumpage values. These conditions and the high cost of protection against fire, ranging from two to four cents per acre, have led lumbermen to believe that scientific forestry is impracticable and that timber lands can only be profitably handled for a single crop. Instances, however, are increasing every year showing that scientific forestry does pay. The Corbin Park of 17,000 acres yields a satisfactory profit, although it is not primarily a lumber investment. The 7,000 acres of the University of the South has yielded during the nine years of forest management over $18,000 above all expenses and the perpetuation of the forest is assured. In 1899 the authorities of the university regarded an

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offer of $3,000 for the merchantable timber with favor. Numerous instances can now be cited of private owners and of paper and pulp companies, of railroads and water companies practicing scientific forestry with profit.

Columbia enters the field of forestry under many favorable conditions. In the first place forestry has to do with many of the departments of the university. Chemistry will deal with the numerous and valuable extracts and distillates derived from timber, pulping processes and the preservation of timber. Mention has been made of the waste in lumbering. Much can be done in utilizing this waste and deriving from it products of great commercial value. Mechanics offers the facilities of its laboratory for testing the strength and resistance of timber, while to engineers the selection of the proper kinds of timber, as well as their care and handling, are important considerations in their work. The work in general and applied geology and soils is of first importance to the forester in explaining the relation of topography to tree distribution and the relation of forest types to soil. This work is not only one of great educational importance, but it promises large returns in advancing forestry through a study of the relation of the geological formations to forest distribution and growth. Botany offers the nature, growth and structure of the tree, its physiological requirements and the study and treatment of plant diseases; while zoölogy will take up the relation of the forest to animal and insect life. Law, medicine and economics are also important contributing factors to the work. Fully 60 per cent. of the work falls within the domain of our present organization.

No forestry school is so fortunate as Columbia's in the facilities offered for practical work. In close proximity to the city are large forest holdings that can be placed under the management of the School, where practical operations can be carried out on a large scale and where plans can be worked out, and where studies on the forest types can be taken up that will make important additions to the science and practice of forestry. Work of this nature is also of great value in that it furnishes a convincing object lesson to the whole community of the value of forestry methods.

There are exceptional opportunities for forest planting in our eastern country. Nearly every farm shows tracts that should never

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have been cleared and that require reforestation, or forest plots that have been improperly handled and require reforesting in part. It is estimated that there are 56 million acres of barren land in the United States, suitable only for forest, that would yield a good return if put out to forest. As yet the total area so treated does not exceed 956,000 acres. It is impossible to estimate the returns that would result from Columbia doing her share in directing such work when we consider the benefit to agriculture, the improvement in the appearance of the land, and the creation of profitable lands from those that are now barren and practically worthless. The benefit that would come from the inauguration of such a policy in the territory 100 miles about New York City would be the greatest that could be conferred. The wood lot, which is the most characteristic feature of the eastern farm, is one of the most important assets of the country. In the estimate of the future forest acreage given above, 100 million acres were in the form of wood lots. Few people realize the economic importance of these scattered timber tracts. In New York state, in spite of the Adirondacks, the product of the wood lots is nearly twice as large as the output of the timber lands. Probably there are some wood lots that are receiving proper treatment to-day, but certainly in the great majority of cases the best trees are constantly being taken out and the inferior and decayed ones are left. As a result the production steadily declines and many lots are little more than brush patches. With a little instruction on the selection of trees, stumpage values and the care of the wood lot the farmer could be taught to see that his wood tract is capable of yielding a steady revenue as well as enhancing the value of his farm. According to the census of 1900 over 110 million dollars worth of wood was cut from the farmers' wood lots. This is nearly two thirds of the total value of the regular lumber industry as it was delivered at the mills.

Finally there is a great field for work in the way of public improvement. Columbia should be a force in shaping the policy for beautifying the streets and improving the parks of our city. There are large tracts of city property in the outlying districts that require proper management at once in order that they may become a desirable part of the park system of the future. This applies also to the water sheds of the city. A wise policy should be inaug-

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urated that would protect these regions against erosion and conserve the water supply. Such a policy carried on about the reservoir catchments would not only protect the water from pollution and improve the scenic beauty, but would also yield an annual revenue above all expense of operation. These two lines alone, coöperation with the city and with owners of farms and estates about the city, would do more to make Columbia known to the people than is being accomplished in any other department. This is no reflection upon the work of any one but it is a fact that the splendid men sent out from our university do not from the nature of their positions make the name of Columbia mean much to the people at large. As far as the people of the community are concerned the name Columbia is unknown, or stands aloof and removed from their interests. In forestry and agriculture the university has a splendid opportunity of performing a patriotic service and of wielding an influence that will make her name mean something in the hearts of the people. The most prosperous universities of to-day, such as the University of Wisconsin and several others, owe their strength and success to this relationship with the people.

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GUIDE TO THE "SIGHT RECOGNITION" SEVENTY IMPORTANT MINERALS.

By A. J. MOSES.

In the "sight recognition" of minerals the characters employed are luster, color, form and structure aided by q obtained "tests" like color of powder ("streak"), appro hardness, cleavage and fracture. That is, the eyes are aide hand glass, a knife and a streak plate.

The purpose of the following paper is to furnish a guide "sight recognition" of average specimens of seventy imp minerals. It is intended to be so arranged and worded tha a little experience the user will be able with little or no ai books, to state accurately *and quickly* that *if the mineral is the seventy* it is one of a certain two or three, and after one confirmatory tests to state which of these it is.

Following the tables are some fifty numbered tests wh principally for elements, but also for fusibility and solubility tests are grouped by kinds.

The minerals selected are:

Iron Minerals.—Pyrrhotite, pyrite, arsenopyrite, magnetit atite, limonite and siderite.

Manganese Minerals.—Pyrolusite.

Cobalt Minerals.—Smaltite.

Nickel Minerals.—Garnierite.

Zinc Minerals.—Sphalerite, smithsonite, calamine.

Tin Minerals.—Cassiterite.

Lead Minerals.—Galenite, cerussite.

Antimony Minerals.—Stibnite.

Copper Minerals.—Copper, chalcocite, bornite, chalcopyr prite, malachite.

Mercury Minerals.—Cinnabar.

Silver Minerals.—Silver, argentite, ruby silver, cerargyri

Gold Minerals.—Gold.

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Potassium, Sodium and Lithium Minerals.—Kainite, halite, soda nitre, lepidolite.

Barium and Strontium Minerals.—Barite, celestite.

Calcium Minerals.—Fluorite, gypsum, apatite, calcite, dolomite.

Magnesium Minerals.—Magnesite.

Aluminum Minerals.—Corundum, cryolite, bauxite.

Borates.—Borax, colemanite.

Sulphur.—Sulphur.

Carbon Minerals.—Diamond, graphite.

Silica.—Quartz, opal.

Silicates (principally the great rock forming silicates).—Orthoclase, plagioclase, pyroxene, amphibole, beryl, garnet, chrysolite, wernerite, zircon, topaz, epidote, tourmaline, stilbite, mica, chlorite, serpentine, talc, kaolinite.

KEY.

A. Minerals as Hard or Harder than Quartz.

In order of hardness 7 to 10, pp. 357 to 358.

B. Minerals Softer than Quartz and Colored both in Mass and in Fine Powder.

The fine Powder is Colored:

1. Black, p. 359.
2. Lead gray to silver white, p. 360.
3. Yellow to yellowish brown, p. 361.
4. Red to reddish brown, p. 362.
5. Green, p. 362.

C. Minerals Softer than Quartz and Distinctly Colored in Mass but White in Fine Powder.

The Mass is Colored:

1. Violet purple or blue, p. 363.
2. Green, p. 364.
3. Yellow or brown, p. 365.
4. Red, p. 367.
5. Gray, p. 368.
6. Black, p. 369.

D. Minerals Softer than Quartz, White in Mass and White in Fine Powder.

1. Will not scratch calcite, p. 370.
2. Will not scratch fluorite, p. 371.
3. Will scratch fluorite, p. 372.

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A. MINERALS AS HARD OR HARDER THAN QUARTZ.

Proof.—A pointed fragment of the mineral rubbed back and forth several times with moderate pressure on a smooth quartz surface will leave a scratch which cannot be brushed away.

Cassiterite or Tin Oxide (SnO_2). H. = 6 to 7. G. = 6.8 to 7.1.

(*a*) Dull heavy kidney-shaped and rounded pebbles brown to red in color.

(*b*) Brilliant heavy brown to black crystals. Often square cross sections, sometimes needle-like.

(*c*) Disseminated grains or heavy brown masses sometimes with structure like wood. **Tests 11, 32, 50.**

Quartz or Silica (SiO_2). H. = 7. G. = 2.6.

(*a*) *Vitreous Quartz.*—Glassy crystals with hexagonal cross section and glassy shapeless material between crystals of other minerals. Usually colorless but in all colors and with many names, such as *amethyst,* if purple to violet; *rose,* if pink; *smoky,* if nearly black; *false topaz,* if brownish yellow, etc.

(*b*) *Chalcedonic Quartz.*—Translucent crusts and cavity linings with smooth rounded surfaces, often in concentric layers with wax like lustre. In all colors and with even more names than vitreous quartz, such as *agate,* if mottled or banded or otherwise varied in color; *carnelian* or *sard,* if brownish red; *onyx,* if banded dark and white; *chrysoprase,* if apple green, etc.

(*c*) *Jasper.*—Nearly or quite opaque material, dull and usually of yellow, brown, red and bluish colors. Takes a good polish and contains enclosed much iron and alumina. **Tests 7 or 15, 32, 50.**

Garnet. Silicate of two or more bases. General formula $R_3''R_2'''(SiO_4)_3$. H. = 6.5 to 7.5. G. = 3.1 to 4.3.

Isometric crystals of easily recognized forms, usually dodecahedron or trapezohedron, more rarely glassy grains or masses. Color varying with composition, most frequently a red brown but may be shades of red or black or rarely yellow and green.

Tests 30, 50, 15.

Tourmaline. A complex boro-silicate. H. = 7 to 7.5. G. = 2.98 to 3.2.

Glassy prismatic hexagonal crystals, the faces differently grouped at the two ends of a crystal. A very common cross section sug-

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gests a triangle. Usually black or very dark, sometimes bright reds, greens, blues or browns. Often found at or near a "contact."

Tests 44, 29, 50.

Zircon ($ZrSiO_4$). H.=7.5. G.=4.68 to 4.70.

Small sharp-cut square prisms, long or short, usually imbedded in the associated mineral. Luster usually adamantine or greasy. Color often brown or gray but more rarely colorless or red or greenish. **Tests 32, 50, 15.**

Beryl ($Be_3Al_2(SiO_3)_6$). H.=7.5 to 8. G.=2.63 to 2.8.

Hexagonal prisms usually with one plane at end. Color varying chiefly in shades of green or yellow. The deep green variety is the emerald and the pale bluish green variety is the aqua-marine. Enormous coarse crystals occasionally found. **Tests 31, 50, 15.**

Topaz ($Al_{12}Si_6O_{25}F_{10}$). H.=8. G.=3.4 to 3.65.

Transparent glassy orthorhombic crystals with essentially rhombic cross sections. The crystals cleave easily into plates in one direction (the cross section) and rarely are found without this cleavage forming at least one end of the crystal. Water-worn crystals occur as pebbles and occasionally very large coarse crystals occur.

Most frequently colorless or pale yellow, less frequently deep brownish yellow or pale blue. **Tests 32, 50, 15.**

Corundum (Al_2O_3). H.=8.5 to 9. G.=3.95 to 4.1.

Varies from coarse crystals of dull color and general hexagonal cross section to brighter colored gem material which may be blue, "sapphire," or red, "ruby," or less frequently yellow, green and purple.

Under corundum is included also "emery" which is a mixture of corundum with a black iron ore.

Frequently partly altered to soft material at surface.

Tests 28, 32, 50.

Diamond (C). H.=10. G.=3.15 to 3.52.

(*a*) Isometric crystals often rounded octahedra with lustre suggesting oiled glass, and cleaving easily at angles of 70°. Colorless, yellowish and rare bright colors.

(*b*) Rounded confusedly crystallized aggregates without distinct cleavage. Gray to black in color. **Tests 32, 50.**

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B. MINERALS SOFTER THAN QUARTZ AND COLORED BOTH IN M AND IN FINE POWDER (Streak).

Proof.—The mineral will not scratch quartz, is colored in m and the fine powder made by grinding or rubbing on a streak p is not white.

Order.—The minerals follow by color of powder. Under streak they are in order of hardness.

1. The Powder is Black.

Graphite (C.). H.=1 to 2. G.=2.1 to 2.2.

"Black lead" or "plumbago" in shining *metallic* flakes masses or dull masses if impure. Soft, greasy and cold tc touch. Will mark paper with shining black STREAK. **Tests 32**

Pyrolusite (MnO_2). H.=1 to 2.5. G.=4.7 to 4.86.

"Black oxide of manganese" in bright but easily bruised l needles or radiating fibers or dull black masses. Will mark p with dull black STREAK. **Tests 6, 32**

Argentite (Ag_2S). H.=2 to 2.5. G.=7.2 to 7.6.

A black silver sulphide which cuts like wax, is very heavy has metallic luster on fresh surface. Often with metallic s Sometimes in cubes and other "isometric" crystals.

Tests 13, 1

Chalcocite (Cu_2S). H.=2.5 to 3. G.=5.5 to 5.8.

Dark shining gray to nearly black copper sulphide with me luster on fresh fracture. Breaks in powder when cut w knife. Often coated with the green carbonate of copper. S times in flat (orthorhombic) crystals, sometimes in nodules, times replacing lignite (wood coal). **Tests 42 or 5, 1**

Bornite (Cu_5FeS_4). H.=3. G.=4.9 to 5.4.

On fresh fracture metallic in luster and a peculiar charact red bronze color. It tarnishes in blue, purple and black tints, variegated. Very brittle and usually massive.

Tests 42 or 5, 1

Chalcopyrite ($CuFeS_2$). H.=3.5 to 4. G.=4.1 to 4.3.

Like bright yellow brass, often tarnishing in brilliant pe colors. Easily cut with a knife and differing in this from py

Tests 42 or 5, 1

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Pyrrhotite (FeS). H.=3.5 to 4.5. G.=4.5 to 4.6.

Bronze-colored masses on fresh fracture, tarnishing brown. Luster metallic. Can be cut with a knife and small particles can be lifted by a steel magnet. **Tests 12, 14, 46.**

Arsenopyrite (FeAsS). H.=5.5 to 6. G.=6 to 6.2.

A hard heavy substance of metallic luster, often in granular masses, tin-white in color. Also in disseminated crystals, the sections of which are rhombic and rectangular. Strikes fire with steel, and at the same time yields an odor like that of garlic.

Tests 2 or 12, 21 or 8 and 14.

Smaltite (CoAsS). H.=5.5 to 6. G.=6.4 to 6.6.

In cubes or in masses resembling arsenopyrite, though a somewhat darker gray, and often associated with a crimson alteration product. **Tests 3, 12, 21 or 8.**

Pyrite (FeS_2). H.=6 to 6.5. G.=4.9 to 5.2.

The very common pale brass-colored cubes, octahedra and other crystals with brilliant metallic lustre. Hard and brittle, striking fire with steel and yielding the odor of burning sulphur. Occurs also in irregular nodules and masses. **Tests 12, 34 or 14.**

Magnetite (Fe_3O_4). H.=5.5 to 6.5. G.=4.9 to 5.2.

The magnetic oxide of iron is black, its streak is black and the steel magnet attracts it strongly. Sometimes it is itself a magnet "lodestone." It occurs in eight-faced (octahedral) crystals, coarse and fine granular masses and as sand. **Tests 2, 48.**

2. The Powder is Lead Gray to Silver White.

Stibnite (Sb_2S_3). H.=2. G.=4.52 to 4.62.

Antimony sulphide or "gray antimony" occurs in soft dark gray masses of brilliant metallic luster, sometimes fine-grained, at others coarsely crystalline. Crystals vary from fine needles to long prisms, and split or cleave into lath-shaped fragments. Sometimes shows "peacock" tarnish. STREAK lead gray.

Tests 9 or 19, 46, 14.

Galenite (PbS). H.=2.5. G.=7.4 to 7.6.

Lead sulphide or galena occurs as soft and *very heavy* dark gray masses of metallic luster which split or cleave with great ease into cubes of brilliant lustre. If fine-grained the cubes may be micro-

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scopic. Crystals are usually cubes or these modified at solid angles. STREAK lead gray. **Tests 16, 14, 33.**

Silver (Ag). H. = 2.5 to 3. G. = 10.1 to 11.1.

Very pale "silver" white when first mined as branching crystals, wire-like filaments, flakes or masses. Tarnishes on exposure, becoming brown to black. Can be cut in shavings, hammered flat or drawn into wire. STREAK silver white. **Tests 13, 33.**

3. The Powder is Yellow to Yellowish Brown.

Sulphur (S). H. = 1.5 to 2.5. G. = 2.05 to 2.09.

Bright translucent material of resinous luster and color varying from pure sulphur yellow to brown. If impure may be gray. Occurs in rhombic crystals which are exceedingly brittle, and as crusts, stalactites and powder. STREAK pale yellow.

Tests 34 or 22, 50.

Gold (Au). H. = 2.5 to 3. G. = 15.6 to 19.3.

Soft exceedingly heavy and very malleable material and metallic luster. Occurs in nuggets, grains and scales in gravels and river beds and disseminated in rocks, especially with sulphides. Usually visible only in occasional specimen and revealed by assay. STREAK golden yellow. **Tests 33, 50.**

Siderite ($FeCO_3$). H. = 3.5 to 4. G. = 3.83 to 3.88.

Occurs with the minerals of ore veins in druses or crusts of curved (rhombohedral) six-sided crystals of brown color and glassy luster. Also occurs as beds of granular massive material, sometimes with easy cleavage at angles of 107°. The STREAK is pale yellow to pale brown. **Tests 12, 35, 46.**

Sphalerite (ZnS). H. = 3.5 to 4. G. = 3.9 to 4.1.

"Black jack" or iron-bearing sphalerite occurs as masses and crystals of nearly black color, showing in places usually a yellow to brown. The luster is strongly resinous and the cleavages if obtained are at 60° and 90°. STREAK pale brown.

Tests 10, 14, 46.

Limonite ($Fe_2(OH)_6$, Fe_2O_3). H. = 5 to 5.5. G. = 3.6 to 4.

"Brown hematite" varies from the brown or yellow loosely compacted "bog ore" and "ochre" to the compact masses often with radiated and stalactitic structure and with nearly black

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varnish-like surfaces. It is never found crystallized. The STREAK is yellowish brown. **Tests 12, 48, 20.**

4. The Powder is Red to Reddish Brown.

Cinnabar (HgS). H.=2 to 2.5. G.=8 to 8.2.

Soft and very heavy fine-grained masses with cochineal to dark brownish red color. Crystalline crusts and disseminated grains. STREAK scarlet. **Tests 23 or 18, 14.**

Ruby Silver [$Ag_3(As.Sb)S_3$]. H.=2 to 2.5. G.=5.57 to 5.86.

A dark red stain or thin crust or, if thicker, then with a brilliant adamantine luster and a color from vermilion to nearly black, the red tint always showing in thin edges or fragments. Six-sided prisms rarely. STREAK from SCARLET to PURPLISH RED. **Tests 13, 14, 8 or 9.**

Copper (Cu). H.=2.5 to 3. G.=8.8 to 8.9.

Unless tarnished is the characteristic *red metal.* If tarnished may be deep red, brown or nearly black. Disseminated grains, sheets and irregular masses or groups of extended and branching isometric crystals. Malleable, sectile and tough. STREAK copper red and shining. **Tests 33, 5 or 42.**

Bauxite ($Al_2O(OH)_4$). H.=1 to 3. G.=2.4 to 2.5.

Soft masses of rounded (concretionary) grains or clay-like. Dull in luster and brown to reddish brown in color. STREAK reddish brown. **Tests 28, 20, 12, 31.**

Cuprite (Cu_2O). H.=3.5 to 4. G.=5.85 to 6.15.

Dark red to nearly black masses with fine-grained almost glassy texture; deep red to crimson isometric crystals, sometimes hair-like. STREAK brownish red shining. **Tests 33, 5 or 42.**

Hematite (Fe_2O_3). H.=5.5 to 6.5. G.=4.9 to 5.3.

(*a*) *Specular Iron.*—Black material of very brilliant metallic luster in thin plate-like or coarser hexagonal crystals and coarse to fine micaceous masses. Occasionally kidney-shaped.

(*b*) *Red hematite.*—Dark red material with little or no luster. May be oölitic, or earthy and ochre-like or fibrous or kidney-shaped. STREAK brownish red. **Tests 12, 48, 2.**

5. The Powder is Green.

Chlorite (Hydrous silicate $Al_2O_3(Fe.Mg)O$). H.=1 to 2.5. G.=2.65 to 2.96.

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Soft blackish green or dark green masses of coarse or fine scales. Sometimes mica-like crystals with easy cleavage into thin flexible but *non-elastic* plates. STREAK pale green.

Tests 20, 15, 50, 12.

Garnierite (Nickel-bearing serpentine). H. = 2 to 3. G. = 2.27 to 2.8.

Soft loosely coherent material varying from bright green to pale green. Without much luster, but sometimes varnish-like or resinous. STREAK pale green. **Tests 4, 7, 32, 20.**

Malachite ($Cu_2(OH)_2CO_3$). H. = 3.5 to 4. G. = 3.9 to 4.03.

Usually a dark green coating or alteration on other copper minerals. If thick may be fine silky fibers or in bands of different shades of green. Crystals rare. STREAK paler green than color.

Tests 5 or 42, 46, 20.

C. MINERALS SOFTER THAN QUARTZ AND DISTINCTLY COLORED IN MASS BUT WHITE IN FINE POWDER.

Proof.—The mineral will not scratch quartz, it is colored in mass but the fine powder made by grinding or rubbing on a streak plate is *white*.

Order.—The minerals follow by color of the mass. Under each color they are in order of hardness.

1. The Mass is Violet, Purple or Blue.

Halite (NaCl). H. = 2.5. G. = 2.95 to 3.

Deep indigo blue portions in masses of common salt with characteristic taste. **Tests 37, 35.**

Calcite ($CaCO_3$). H. = 3. G. = 2.71 to 2.72.

Pale blue masses which break into six-faced forms with angles of 105° between faces. Occasional bright blue and purple crusts colored by copper or cobalt. **Tests 40, 46, 32.**

Celestite ($SrSO_4$). H. = 3 to 3.5. G. = 3.95 to 3.97.

Heavy pale blue orthorhombic crystals with cleavage to rhombic plates of 76°. Also fibrous masses. **Tests 39, 14, 29, 50.**

Fluorite (CaF_2). H. = 4. G. = 3.01 to 3.25.

Violet blue and greenish blue transparent cubes and masses of glassy luster which cleave in four directions, yielding angles of 109½° and 70½°. **Tests 40, 24, 29, 48.**

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Opal ($SiO_2 + nH_2O$). H.=5.5 to 6.5. G.=2.1 to 2.2.

Pale blue vitreous material, translucent and breaking with shell-like fracture. **Tests 20, 15, 32, 50.**

2. The Mass is Green.

Talc ($H_2Mg_3(SiO_3)_4$). H.=1 to 1.5. G.=2.55 to 2.87.

Very pale green foliated masses with soapy feeling. Breaks into non-elastic plates. **Tests 20, 27, 31, 50.**

Cerargyrite (AgCl). H.=1 to 1.5. G.= 5 to 5.5.

Thin greenish crusts, darkening in sunlight and cutting like wax. Shining surface after cutting. **Tests 25, 13.**

Chlorite (Hydrous silicate $Al_2O_3(Fe.Mg)O$). H.=1 to 2.5. G.=2.65 to 2.96.

Grass green to dark green mica-like crystals with pearly luster which cleave to thin, flexible but not elastic plates. Also masses of coarse to fine scales. **Tests 20, 15, 50, 31.**

Serpentine ($H_4Mg_3Si_2O_9$). H.=2.5 to 4. G.=2.5 to 2.65.

Masses of mottled shades of green and yellow with little luster, veins of parallel silky fibers (asbestos) and masses which break in leaves. **Tests 20, 27, 31, 49.**

Fluorite (CaF_2). H.=4. G.=3.01 to 3.25.

Green and greenish blue transparent glassy cubes and masses which cleave in four directions, yielding angles of 109½° and 70½°. **Tests 24, 40, 29, 48.**

Apatite ($Ca_5(Cl.F)(PO_4)_3$). H.=5. G.=3.17 to 3.23.

Six-sided prisms terminated by pyramids, bluish green or sea green with luster of oiled glass. Imperfect cleavage into hexagonal blocks. **Tests 40, 45, 31, 48.**

Pyroxene ($RSiO_3$). H.=5 to 6. G.=3.2 to 3.6.

Varying from pale transparent monoclinic crystals through shades of dull green to nearly black. Luster glassy. Cross-section usually eight-sided with angles between *alternate* faces either 90° or near 90° (87° and 93°), not fibrous.

Tests 30, 50, sometimes 12.

Amphibole ($RSiO_3$). H.=5 to 6. G.=2.9 to 3.4.

Dull and dark green monoclinic crystals with rhombic or six-sided cross-section, with angles between adjacent faces near 120° (124° or 116°). Also radiating and parallel mass of fibers and thin crystals. **Tests 30, 50, sometimes 12.**

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Wernerite (Silicate $Al_2O_3.CaO$). H.=5 to 6. G.=2.66 to 2.73.

Dull green club-shaped tetragonal crystals with eight-sided or square cross-section. Angles 135° and 90°. Cleavages at same angles and with faintly fibrous appearance. **Tests 29, 49.**

Opal (SiO_2nH_2O). H.=5.5 to 6.5. G.=2.1 to 2.2.

Pale green vitreous material breaking with shell-like fracture.

Tests 20, 15, 32, 50.

Epidote (Silicate $(Ca.Fe)OAl_2O_3$). H.=6 to 7. G.=3.25 to 3.5.

A secondary mineral often in and with the original mineral as grains or needles of a peculiar yellowish green color (pistachio-green). Less frequently in blackish green monoclinic crystals.

Tests 30, 50, 20.

Chrysolite ($(Mg.Fe)_2SiO_4$). H.=6.5 to 7. G.=3.27 to 3.57.

Translucent pale yellowish green grains, forming masses or sand or disseminated in volcanic rocks or in other minerals.

Tests 32, 47.

3. The Mass is Yellow or Brown.

Cerargyrite (AgCl). H.=1 to 1.5. G.=5 to 5.5.

Violet brown crusts resulting from action of light on the mineral. Cuts like wax and the cut is shining. **Tests 25, 13.**

Gypsum ($CaSO_4.2H_2O$). H.=1.5 to 2. G.=2.31 to 2.33.

Easily cleavable monoclinic crystals of pale yellowish brown color and transparent. The cleavages form a rhombic plate with angle of 66°. **Tests 40, 14, 29, 48.**

Sulphur (S). H.=1.5 to 2.5. G.=2.05 to 2.09.

Bright translucent orthorhombic crystals and masses of "sulphur" yellow, less frequently greenish yellow or yellowish brown. Impure dull grayish yellow material. **Tests 34 or 22, 50.**

Halite (NaCl). H.=2.5. G.=2.4 to 2.6.

Common rock salt irregularly brown from visible inclusions. Becomes damp on exposure, has characteristic taste and breaks into cubic fragments. **Tests 37, 35.**

Serpentine ($H_4Mg_3Si_2O_9$). H.=2.5 to 4. G.=2.5 to 2.65.

Masses and silky fibers of dull yellow color. More rarely brown masses. Very little luster. **Tests 20, 27, 31, 49.**

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Cryolite ($AlNa_3F_6$). H.=2.5. G.=2.95 to 3.

Translucent dull brown material suggesting a brownish wax.

Tests 37, 28, 25, 29, 48.

Barite ($BaSO_4$). H.=2.5 to 3.5. G.=4.3 to 4.6.

Heavy masses of brown color and transparent yellow to brown orthorhombic crystals which break into rhombic plates, the rhomb angle being 78½°. **Tests 41, 14, 35, 50.**

Calcite ($CaCO_3$). H.=3. G.=2.71 to 2.72.

Very common transparent or translucent pale yellowish brown hexagonal crystals of many shapes which all cleave to rhombohedra with an angle between faces of 105°. **Tests 40, 46, 32.**

Cerussite ($PbCO_3$). H.=3 to 3.5. G.=6.46 to 6.57.

Impure dull twinned orthorhombic crystals and masses of dull yellow color. Very heavy and brittle, and often with galenite.

Tests 16, 46, 50.

Sphalerite (ZnS). H.=3.5 to 4. G.=3.9 to 4.1.

Transparent yellow to molasses brown isometric crystals and cleavable masses ("rosin jack"), with strong resinous luster. Also fine-grained. **Tests 10, 14, 46.**

Siderite ($FeCO_3$). H.=3.5 to 4. G.=3.83 to 3.88.

"Druses" of curved six-sided hexagonal crystals and cleavable masses of gray to brown color. Both yielding angles of 107°. Also gray to brown granular masses. **Tests 12, 46, 35.**

Stilbite (Hydrous silicate $CaO.Al_2O_3$). H.=3.5 to 4. G.=2.09 to 2.2.

One of the many so-called zeolites found in cavities in igneous rocks. It occurs as sheaf-like and radiated groups of crystals of dull brown color. The crystals show pearly luster on larger faces.

Tests 36, 29, 48.

Fluorite (CaF_2). H.=4. G.=3.01 to 3.25.

Transparent wine yellow and rarely brown cubes and masses of glassy luster which cleave into forms of four and eight faces with angles between faces of 109½° and 70½°. **Tests 24, 40, 29, 48.**

Calamine $(ZnOH)_2SiO_3$. H.=4.5 to 5. G.=4.3 to 4.5.

Pale yellow to pale brown masses, the cavities in which are lined with orthorhombic crystals, often only ends showing, but these usually parallel, forming ridges or combs. The fracture shows the crystals like parallel fibers. **Tests 10, 47, 31, 20.**

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Smithsonite ($ZnCO_3$). H. = 5. G. = 4.3 to 4.5.

Dull brown and rarely bright yellow crusts with smooth rounded surfaces. Occasionally showing hexagonal crystal ends which are three-faced. **Tests 10, 46, 32.**

Opal (SiO_2nH_2O). H. = 5.5 to 6.5. G. = 2.1 to 2.2.

Ocher yellow, wax yellow and amber brown masses with shell-like fracture. Often with structure of wood.

Tests 20, 15, 32, 50.

Orthoclase ($KAlSi_3O_8$). H. = 6 to 6.5. G. = 2.44 to 2.62.

Pale yellow masses and monoclinic crystals which cleave in two directions exactly at right angles. The resultant surfaces do not show grooves. **Tests 43, 31, 50.**

Chrysolite ($(MgFe)_2SiO_4$). H. = 6.5 to 7. G. = 3.27 to 3.57.

Translucent glassy grains of greenish yellow color which may exist as sand or in other minerals or as masses. **Tests 32, 47.**

4. The Mass is Red.

Gypsum ($CaSO_42H_2O$). H. = 1.5 to 2. G. = 2.31 to 2.33.

Flesh red or, if impure, brownish red masses which are made up of pearly scales. Under the glass these are seen to cleave to rhombic plates with angle of 66°. **Tests 40, 14, 20, 29, 48.**

Lepidolite (Silicate $(Li_2K_2)OAl_2O_3$). H. = 2 to 2.5. G. = 2.8 to 3.2.

"Lithia mica" in fine scaly masses of rose to cherry red color.

Tests 38, 7, 29.

Calcite ($CaCO_3$). H. = 3. G. = 2.71 to 2.72.

Pale pink transparent hexagonal crystals or impure more nearly opaque iron red masses and crystals. The cleavage in three directions at 105° to each other yields six-sided form.

Tests 40, 46, 32.

Kainite ($KCl.MgSO_4.3H_2O$). H. = 2.5 to 3. G. = 2 to 2.2.

Granular sugar-like masses of brownish red color and disagreeable taste. **Tests 43, 27, 14, 20.**

Fluorite (CaF_2). H. = 4. G. = 3.01 to 3.25.

Pale rose red eight-faced crystals (octahedra), which cleave parallel to the bounding faces. **Tests 24, 40, 29, 48.**

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Dolomite ($CaMg(CO_3)_2$). H. = 3.5 to 4. G. = 2.8 to 2.9.

Cavities in limestone are sometimes lined with numerous small pink rhombohedral crystals with curved edges and faces.

Tests 40, 27, 46, 32.

Apatite ($Ca_5(Cl.F)(PO_4)_3$). H. = 5. G. = 3.17 to 3.23.

Six-sided prisms with pyramid terminations often brownish red or mottled with green. The luster resinous or like oiled glass. Imperfect cleavage into hexagonal blocks. **Tests 40, 45, 31, 48.**

Plagioclase (Silicate $(Ca.Na_2)OAl_2O_3$). H. = 5 to 7. G. = 2.6 to 2.7.

Triclinic crystals and flesh-colored or brownish red masses which cleave in two directions *nearly* at right angles and show parallel grooves (striations) on the cleavage surfaces.

Tests 37, 50, 31, sometimes 29.

Orthoclase ($KAlSi_3O_8$). H. = 6 to 6.5. G. = 2.44 to 2.62.

Pink to flesh-colored masses and monoclinic crystals, which cleave in two directions at right angles and yield smooth ungrooved surfaces. **Tests 43, 31, 50.**

Opal (SiO_2nH_2O). H. = 5.5 to 6.5. G. = 2.1 to 2.2.

Transparent or translucent material with red and yellow reflections (fire opal), or more opaque jasper-like masses with glassy luster and dark-red color. **Tests 20, 15, 32, 50.**

5. The Mass is Gray.

Gypsum ($CaSO_4.2H_2O$). H. = 1.5 to 2. G. = 2.31 to 2.33.

Fine-grained compact gray rock gypsum.

Tests 40, 14, 20, 29, 48.

Mica (Silicate $K_2OAl_2O_3$). H. = 2 to 2.5. G. = 2.76 to 3.

Silvery or pearly gray masses of scales and crystals of muscovite which break easily into thin transparent very elastic plates.

Tests 31, 50, sometimes 20.

Cerussite ($PbCO_3$). H. = 3 to 3.5. G. = 6.46 to 6.57.

Gray translucent material, very heavy and with brilliant luster on fresh fracture. **Tests 16, 46, 50.**

Calcite ($CaCO_3$). H. = 3. G. = 2.71 to 2.72.

Compact gray limestone. **Tests 40, 46, 32.**

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Dolomite ($CaMg(CO_3)_2$). H. = 3.5 to 4. G. = 2.8 to 2.9.
Compact gray limestone. **Tests 40, 27, 46, 32.**

Siderite ($FeCO_3$). H. = 3.5 to 4. G. = 3.83 to 3.88.
Compact fine-grained gray masses, often brown externally.
Tests 12, 46, 35.

Wernerite (Silicate Al_2O_3CaO). H. = 5 to 6. G. = 2.66 to 2.73.
Pearl gray and whitish gray club-shaped tetragonal crystals, with octagonal or square cross-section. Angles 135° or 90°. Faintly fibrous on cleavage surface. **Tests 29, 49.**

Amphibole ($RSiO_3$). H. = 5 to 6. G. = 2.9 to 3.4.
Gray silky radiating material and gray monoclinic crystals with rhombic or six-sided cross-section. The angle of rhomb is 124° and in the six-sided the angles are 124° and 116°. **Tests 30, 50.**

Plagioclase (Silicate $(CaNa_2)OAl_2O_3$). H. = 5 to 6. G. = 2.7 to 2.72.
The feldspar labradorite in gray masses which cleave in two directions at 86°, the resulting surfaces showing parallel grooves (striations). Usually shows beautiful play of colors.
Tests 37, 31, 50, sometimes 29.

6. The Mass is Black.

Mica (Silicate $(Mg.K_2)OAl_2O_3$). H. = 2.5 to 3. G. = 2.7 to 3.1.
The very common black scales in crystalline rocks which cleave into thin elastic plates are biotite. **Tests 31, 50 sometimes 20.**

Pyroxene (Augite) ($RSiO_3$). H. = 5 to 6. G. = 3.2 to 3.6.
Usually short prismatic monoclinic crystals with eight-sided cross-section with angles between alternate faces 90° or 87°.
Tests 12, 50.

Amphibole (Hornblende) ($RSiO_3$). H. = 5 to 6. G. = 2.9 to 3.4.
Short prismatic monoclinic crystals with six-sided cross section, the angles being 124° and 116°. Also in long blade-like and fibrous masses with luster of horn. **Tests 12, 50.**

Rare varieties of fluorite and dolomite are black.

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D. MINERALS SOFTER THAN QUARTZ WHITE IN MASS AND WHITE IN FINE POWDER.

(This would include colorless and *very* pale tints.)

Proof.—The mineral will not scratch quartz, it is white in mass and the fine powder, made by grinding or rubbing on a streak plate, is white.

Order.—The minerals are in order of their hardness, first in terms of calcite and fluorite, then on the Mohs scale.

1. Will not Scratch Calcite.

Talc ($H_2Mg_3(SiO_3)_4$). H. = 1 to 1.5. G. = 2.55 to 2.87.

A very soft gritless material with soapy feeling. Occurs foliated, with pearly luster or fine-grained or wax-like. Will cut without crumbling. **Tests 20, 27, 31, 50.**

Cerargyrite (AgCl). H. = 1 to 1.5. G. = 5 to 5.5.

Usually thin crusts which look and cut like horn or wax. Luster resinous. **Tests 25, 13.**

Soda Nitre ($NaNO_3$). H. = 1.5 to 2. G. = 2.24 to 2.29.

Usually fine-grained masses which become damp on exposure and have the so-called "cooling" taste. **Tests 26, 37.**

Gypsum ($CaSO_4.2H_2O$). H. = 1.5 to 2. G. = 2.31 to 2.33.

Soft cleavable monoclinic crystals and masses, which, unless very fine-grained, will show rhombic fragments with the angle of 66°. Sometimes silky fibrous (satin spar) or fine compact (alabaster). **Tests 40, 14, 20, 29, 48.**

Kaolinite ($H_4Al_2Si_2O_9$). H. = 2 to 2.5. G. = 2.6 to 2.63.

Minute scales of pearly luster, flexible but not elastic. The name is often used for dull white clay-like or mealy masses which become highly plastic. **Tests 28, 32, 50.**

Borax ($Na_2B_4O_7.10H_2O$). H. = 2 to 2.5. G. = 1.69 to 1.72.

Glistening white crusts or translucent monoclinic crystals which become snow white. Taste alkaline. **Tests 44, 37, 20, 36.**

Mica (Muscovite). H. = 2 to 2.5. G. = 2.76 to 3.

Crystals which break easily into thin elastic transparent plates with pearly luster and confused aggregates of coarse and fine scales which cleave in the same way. **Tests 31, 50, sometimes 20.**

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Lepidolite (Silicate $(Li_2.K_2)O.Al_2O_3$). H.=2 to 2.5. 2.8 to 3.2.

Fine scaly masses each scale cleaving easily into thinner pla

Tests 38,

Halite (NaCl). H.=2.5. G.=2.4 to 2.6.

Masses which cleave to cubes and have the characteristic of common salt. Isometric crystals often with hollow faces. comes damp on exposure. **Tests 3**

Cryolite ($AlNa_3F_6$). H.=2.5. G.=2.95 to 3.

Translucent material, the luster and texture resembling s aceti or frozen snow. Rarely little six-sided crystals, nearly

Tests 32, 28, 25, 2

Kainite ($KCl.MgSO_4.3H_2O$). H.=2.5 to 3. G.=2 to

Granular sugar-like masses with disagreeable taste.

Tests 43, 27, 1

Bauxite ($Al_2O(OH)_4$). H.=1 to 3. G.=2.4 to 2.5.

Soft masses of rounded grains or clay-like. Luster dull.

Tests, 28,

Barite ($BaSO_4$). H.=2.5 to 3.5. G.=4.3 to 4.6.

Heavy masses and orthorhombic crystals which break easi rhombic grains and plates. The rhomb angle is 78½°. O crystals with metallic ores. **Tests 41, 14,**

Celestite ($SrSO_4$). H.=3 to 3.5. G.=3.95 to 3.97.

Very similar to barite. Less often in large masses, often a pale blue tinge. Angle of cleavage rhomb 76°.

Tests 39, 14,

2. Will Scratch Calcite but not Fluorite.

Barite and celestite above described as well as unusuall specimens of *bauxite* and *kainite* may work out in this divi

Calcite ($CaCO_3$). H.=3. G.=2.71 to 2.72.

Transparent and translucent hexagonal crystals of many all of which will break into six-faced forms (rhombohedr angle between adjacent cleavages being 105°. Also g masses, each grain cleaving as a crystal. Foliated and masses rare. **Tests 40,**

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Cerussite ($PbCO_3$). H. = 3 to 3.5. G. = 6.46 to 6.57.

Very heavy masses and orthorhombic crystals, sometimes translucent and with adamantine luster, sometimes milk white silky fibers. Very brittle. **Tests 16, 46, 50.**

Dolomite ($CaMg(CO_3)_2$). H. = 3.5 to 4. G. = 2.8 to 2.9.

Small curved six-faced hexagonal crystals, usually in large numbers lining a cavity or incrusting some other mineral. Also in masses of granular material, each grain cleaving to six-faced forms with 106° between adjacent faces. **Tests 40, 27, 46, 32.**

Stilbite (Hydrous silicate $CaOAl_2O_3$). H. = 3.5 to 4. G. = 2.09 to 2.2.

(One of the many so-called zeolites which occur in cracks and seams in igneous rocks as a result of alteration.) Sheaf-like groups of nearly parallel crystals or radiated groups of divergent crystals. Usually thin tabular crystals with pearly luster on the larger faces only. **Tests 36, 29, 48.**

Magnesite ($MgCO_3$). H. = 3.5 to 4.5. G. = 3 to 3.12.

Compact material like unglazed porcelain with marked rounded shell-like fracture. More rarely chalk-like. Not often in crystals. **Tests 27, 46, 32.**

3. Will Scratch Fluorite.

Magnesite just described may work out in this division.

Fluorite (CaF_2). H. = 4. G. = 3.01 to 3.25.

Cubic crystals and masses of glassy luster which break in four directions into four-faced or eight-faced forms with angles of 109½° or 70½°. **Tests 24, 40, 29, 48.**

Calamine ($(ZnOH)_2SiO_3$). H. = 4.5 to 5. G. = 3.4 to 3.5.

Masses and crusts with surface made of orthorhombic crystal ends (drusy) sometimes forming ridges, because of parallel position. When broken the fracture shows the grouped crystal-like fibers at right angles to drusy surface. **Tests 10, 47, 31, 20.**

Smithsonite ($ZnCO_3$). H. = 5. G. = 4.3 to 4.5.

Masses with smooth rounded surfaces sometimes suggesting chalcedony. Porous cellular masses and rarely "drusy" surfaces, the hexagonal crystal ends being three-faced. **Tests 10, 46, 32.**

Apatite ($Ca_5(ClF)(PO_4)_3$). H. = 4.5 to 5. G. = 3.17 to 3.23.

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Dull white six-sided hexagonal prisms with pyramid compact bone-like masses. Rarely glassy crystals.

Tests 40, 45

Pyroxene ($RSiO_3$). H.=5 to 6. G.=3.2 to 3.6.

Monoclinic crystals. Cross-section usually eight-sided, the sides constituting a rectangle, the alternate four a rho angle of 87°. Not fibrous. **Test**

Amphibole ($RSiO_3$). H.=5 to 6. G.=2.9 to 3.4.

Blade-like monoclinic crystals with rhomb cross-sect rhomb angle 124°, or short thick six-sided crystals with nearly a true hexagon but actual angles 124° and 116°. fibrous masses. **Test**

Wernerite (Silicate $Al_2O_3.CaO$). H.=5 to 6. G.= 2.73.

Coarse thick club-shaped tetragonal crystals. Octa square cross-section (angles 135° or 90°). Cleavages w angles and with faintly fibrous appearance. **Tes**

Opal ($SiO_2 + nH_2O$). H.=5.5 to 6.5. G.=2.1 to

Translucent material sometimes with beautiful internal flections. More often without "opalescence" and with l tendency to break in curves (shell-like). **Tests 20, 1**

Plagioclase (Silicate $(Na_2Ca)OAl_2O_3$). H.=5 to 7. to 2.7.

Masses and triclinic crystals which break smoothly directions at angles nearly but not exactly 90°. The resulting often show parallel grooves (striations). S opalescent. **Tests 37, 31, 50, some**

Orthoclase ($KAlSi_3O_8$). H.=6 to 6.5. G.=2.44 t

Masses and monoclinic crystals which cleave in two at exactly 90° to each other. The surfaces resulting grooved. Sometimes opalescent. **Tests 4**

THE FIFTY TESTS.*

Although in general it may be assumed that the us scheme has access to works on blowpipe analysis, a brie tion of each test is given for convenience.

* The *essential* pieces of apparatus for all the tests given are:

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It is recommended that before testing minerals a few preliminary tests be made, for instance in order 1, 5, 6, 10, 13, 16, 20, 23, 27, 30, 40, 42, 47. This will greatly increase the accuracy of the subsequent testing.

By elements etc., the numbers are as follows:

Element.	Test.	Element.	Test.
Aluminum	28	Manganese	6
Antimony	9, 19	Mercury	18, 23
Arsenic	8, 21	Molybdenum	1
Barium	41	Nickel	4, 12
Bismuth	17	Nitrates	27
Boron	44	Phosphorus	45
Calcium	40	Potassium	43
Carbonates	46	Silica	7, 15
Chlorine	46	Silver	13, 25
Cobalt	3, 12	Sodium	37
Copper	5, 42	Strontium	39
Fluorine	24	Sulphur	14, 22, 46
Iron	2, 12	Tin	11
Lead	16	Zinc	10
Lithium	38	Fusibility 29 to 36.	
Magnesium	27	Solubility 46 to 52	

Bead Tests* with Borax.

Make a loop in platinum wire.

Bend it around a pencil point so that the end meets but does not cross the straight part.

Heat the loop, dip it into borax and fuse the portion that adheres to a clear bead. Add more borax until the bead is of full rounded shape.

1. Either a gas blowpipe or some form of burner for gas or heavy oil and a plain blowpipe.

2. Platinum wire about .25 mm. diameter. Six inches will make four wires. A holder will be needed.

3. Platinum-pointed forceps.

4. Charcoal in convenient sizes and with smooth surfaces (say 4″×1″×5/16″).

For the other apparatus considerable latitude is possible and substitutes can be improvised for the regular stock article. The needed list would be watch glasses, bottles (1 oz.) for reagents, hammer, anvil, magnet.

For satisfactory work a good hand glass is very desirable.

* For safety substances should first be heated with gentle flame on coal to drive off volatile compounds. Use a dull red heat and continue as long as fumes are given off.

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Blow an oxidizing flame (O. F.).

If a lamp or Bunsen burner is used place the tip of the blowpipe almost touching the top of the burner, or the wick, and extending in one-third the breadth of the flame. With the gas blowpipe all that is necessary is to avoid an excess of gas.

Touch the warm bead to the substance, place it in the colorless mantle which surrounds the blue flame and treat until clear. Note the colors hot and cold.

Then blow a reducing flame (R. F.).

If a lamp or Bunsen burner is used, place the tip of the blowpipe one eighth of an inch above and back of the middle of the flame, and turn the entire flame in the direction of the blast. With the gas blowpipe reduction is obtained by using a larger flame and inserting the bead within the yellow.

1. **Purity* of flames.**

Dip the hot bead into the MoO_3, dissolve the adhering material at the tip of the blue flame and make the bead alternately brown or black in the reducing flames and colorless in the oxidizing flame.

2. **Iron, Fe.** O. F. Yellow to red hot, colorless to yellow cold. R. F. Bottle green.

3. **Cobalt, Co.** Pure deep blue in either flame.

4. **Nickel, Ni.** O. F. Violet hot, pale reddish-brown cold. R. F. Cloudy and finally clear and colorless.

5. **Copper, Cu.** O. F. Green hot, blue or greenish-blue cold. R. F. Greenish to colorless hot, opaque brownish red when cold.

Bead Tests with Salt of Phosphorus.

The bead is made on platinum wire as described for borax, except that in the making the bead should be held a little above the flame so that the ascending hot gases will help to retain the flux upon the wire.

The substance is added gradually to the warm bead and fused with it in the oxidizing flame.

The substances best determined by this test are:

6. **Manganese, Mn.** O. F. Amethystine hot, reddens on cooling.

* Manganese dioxide may be used instead. A borax bead is dipped while hot into the MnO_2 and heated in the oxidizing flame; if only a little MnO_2 is used the bead becomes violet-red when cold. It can be made colorless in the reducing flame by steady blowing. If more is used the bead will be nearly black when cold before reduction and amethystine after reduction.

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If a hot dilute bead is touched to a crystal of sodic nitrate a rose-colored froth is formed.

7. Silica, SiO_2. Insoluble. The test made upon a small fragment will usually show a translucent mass of undissolved matter of the shape of the original fragment.

Coatings and other Tests upon Charcoal either without Fluxes or mixed with Soda (Sodium Carbonate Dry).

A shallow cavity, sufficient to prevent the substance slipping, is bored at one end of the charcoal and a little of the substance is placed in it. The charcoal is held in the left hand, so that the surface is tipped at about 120° to the direction in which the flame is blown.

A gentle oxidizing flame is blown, the blue flame not touching the substance, but being just behind and in a line with it. If no sublimate forms the heat is increased, still keeping the flame oxidizing.

Any sublimate obtained is noted as to position, color, ease of driving with flame, etc.

After volatilization ceases with the oxidizing flame the reducing flame is used, the substance being kept covered for several minutes with the yellow flame.

The following substances are often determined by this test.

8. Arsenic, As. Very volatile white coat and strong garlic odor. Fumes invisible near assay after removal of flame. Soda assists the reaction.

9. Antimony, Sb. White volatile coat. The fumes are visible close to assay after removal of flame.

10. Zinc, Zn. Yellow non-volatile coat, white when cold. Best in R. F. with soda. If the coat is moistened with cobalt solution and strongly heated it becomes bright *yellowish* green.

11. Tin, Sn. Strongly heated forms a yellow coat, white when cold. Best in R. F. with soda. If the coat is moistened with cobalt solution and strongly heated it becomes *bluish* green.

12. Iron, Cobalt or Nickel. Many compounds become magnetic in R. F. Soda assists the reaction.

13. Silver, Ag. Silver minerals heated on charcoal are decomposed and a malleable "button" results which if dissolved in a

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drop of nitric acid will yield a white curd-like precipitate on addition of a drop of hydrochloric acid.

14. Sulphur, S. Sulphides or sulphates mixed with soda and a little borax and thoroughly fused in the R. F., placed on bright silver, moistened, crushed and let stand, the silver will be stained brown to black.

15. Silica, SiO_2. Mixed with soda, silica and silicates dissolve with effervescence to a bead which may be clear or opaque.

Coatings on Charcoal and Plaster* with Bismuth Flux.†

The sublimates obtained on charcoal and plaster differ in position, and to some extent in color and supplement each other.

The method of using charcoal and plaster is the same.

The following elements are often determined by this test:

16. Lead, Pb. *On Plaster.*—Chrome yellow coat.

On Charcoal.—Greenish-yellow, equally voluminous coat.

17. Bismuth, Bi. *On Plaster.*—Chocolate-brown coat, with an underlying scarlet, with ammonia it becomes orange-yellow, and later cherry-red.

On Charcoal.—Bright red band with a fringe of yellow.

18. Mercury, Hg. *On Plaster.*—Scarlet coat with yellow, but if the substance is quickly heated the coat is dull yellow and black.

On Charcoal.—Faint yellow coat.

19. Antimony, Sb. *On Plaster.*—Orange coat stippled with peach-red.

On Charcoal.—Faint yellow coat.

E. TESTS IN CLOSED TUBES.

A plain narrow glass tube about 3 inches by $\frac{3}{16}$ inch and closed at one end is best.

Enough of the substance is slid down a narrow strip of paper, previously inserted in the tube, to fill it to the height of about one

* Plaster tablets are prepared by making a paste of plaster of Paris and water, just thick enough to run, which is spread out upon a sheet of oiled glass and smoothed to a uniform thickness ($\frac{1}{8}$" to $\frac{1}{4}$"). While still soft, the paste is cut with a knife into uniform slabs, 4" by 1½". It is then dried, after which the tablets are easily detached.

† Two parts of sulphur, one part of potassium iodide, one part of acid potassium sulphate.

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quarter inch; the paper is withdrawn and the inclined tube heated at the lower end gradually to a red heat.

Soda or other reagents are sometimes mixed with the substance.

The following substances are often determined by this test:

20. Water, H_2O. Drops of moisture condense in the upper part of the tube. Sometimes the moisture is obtained at a low temperature, sometimes only at red heat.

21. Arsenic and its Compounds. May yield white oxide, yellow or red sulphide, or black mirror of metal. If the tube is broken and the mirror heated, a strong garlic odor will be noticed. Smaltite does not yield the red sublimate, arsenopyrite does.

22. Sulphur and Sulphides. May yield sublimate of sulphur red when hot, yellow cold, or sublimate of undecomposed sulphide.

23. Mercury, Hg. Compounds mixed with dry soda and heated yields a mirror which may be collected into globules on a match.

24. Fluorine, F. Mixed with $KHSO_4$ and heated will corrode the glass in cloudy patches, which cannot be washed off.

25. Cerargyrite, AgCl, with $KHSO_4$ yields a globule yellow hot, white cold, becoming violet in sunlight.

26. Nitrates, with $KHSO_4$ yield brown fumes with characteristic odor.

Tests with Cobalt Solution.*

Certain substances moistened with cobalt solution and heated to red or white heat become colored. The test is usually made upon charcoal.

The elements usually determined in this way are:

27. Magnesium, Mg. The substance moistened with the solution and *strongly* heated becomes a pale flesh or pink color. The arsenate, borate and phosphate become dark violet.

28. Aluminum, Al. Tested as for magnesium becomes fine blue when cold.

The test is also made upon sublimates supposed to be wholly or in part zinc oxide or tin oxide.

Fusible compounds remain in doubt as many are colored blue by cobalt notably borax and calamine.

* Cobalt nitrate dissolved in ten parts of water.

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Fusibility.

The relative ease of fusibility and the phenomena during fusion (or manner of fusion) are convenient tests in many instances.

The test will be most safely made as follows:

(*a*) If metallic or reducible, treat in a shallow hole on charcoal, using a fragment of the substance the size of a pin's head.

(*b*) If stony or vitreous, a small fragment with an edge as thin as paper *and long enough to project* say 1/8" beyond the platinum forceps is selected and held in the hottest portion of the flame just beyond the tip of the blue. The flame should be directed especially on the point. The fragments should be examined with a magnifying glass *before* and *after* heating to determine whether the edges have or have not been rounded by the heat.

The degree or ease of fusibility may be given as:

29. Easily to a white enamel or colorless glass. Ex. Gypsum.

30. Easily to a colored enamel or glass. Ex. Garnet.

31. With difficulty or only on the edges. Ex. Orthoclase or calamine.

32. Infusible. Ex. Quartz.

Certain phenomena on heating on charcoal, and not previously recorded, are sometimes available as tests.

33. Leaves a malleable metal.

34. Takes fire and burns with odor of SO_2.

35. Flies to pieces.

36. Swells considerably.

Flame Coloration.

At the time of making the fusion test there may be weak or strong flame coloration, that is, the non-luminous mantle may become colored.

It is best in every case whether this was observed or not to make a test using the blowpipe flame and not the Bunsen burner alone as follows:

Powder the substance finely. Flatten the end of a clean platinum wire and dip it first in dilute hydrochloric acid, then in the powder. Arrange a black background such as a piece of charcoal.

Hold the wire now first in the mantle flame near the wick and then at the hottest portion at the tip of the blue flame. Again dip in the acid and place in the flame.

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The elements often determined by this test are:

37. **Sodium.** Bright yellow.
38. **Lithium.** Carmine red.
39. **Strontium.** Crimson.
40. **Calcium.** Red.
41. **Barium.** Yellowish green.
42. **Copper.** Azure blue.
43. **Potassium.** Violet (pale).

Certain elements are best determined by flames obtained from substances dipped in concentrated sulphuric acid.

44. **Boron.** Yellowish green. 45. **Phosphorus.** Bluish green.

Solubility.

Acids, especially dilute (1 : 1) hydrochoric acid are used not only to determine composition but to determine the ease or degree of solubility.

The substance must be finely ground and small quantities added at a time to the cold dilute acid in a watch glass.

The acid is then slowly heated; all phenomena are noted.

A clear solution should be aimed for, acid being added if more is needed until everything has dissolved. If this cannot be done decant or filter the liquid.

The clear solution should now be slowly and partially evaporated till separation commences.

The more important results *with hydrochloric acid* may be stated.

46. **Effervescence.**

If the substance is non-metallic in lustre the gas given off will almost always be CO_2 showing that the substance was a carbonate. H_2S is easily recognized by its odor. Cl is yellowish and very offensive.

47. **Gelatinous Residue.** If a jelly forms after boiling away the larger part of the acid a silicate was present.

48. Easily soluble without effervescence.

49. Soluble partially or with difficulty.

50. Insoluble or nearly so.

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RELATION OF THE OLDER TO THE YOUNGER GRADUATE.*

By CHARLES BUXTON GOING.

In a paper read last June before the Society for the Promotion of Engineering Education, I drew a contrast between civil and military education and pointed out what seemed to me a striking difference. The cadet at West Point or Annapolis upon graduation changes his official designation, changes his uniform, and changes to some extent his day's work; but he changes in the most trifling degree, if at all, his environment, his atmosphere, his functions, the relations to his associates or to his job. The army or navy is simply a wider circle concentric with the military or naval academy. The ensign or the lieutenant steps out confidently on the same path and in exactly the same direction as the cadet.

But the graduate of a civil-engineering course (I am using civil engineering in the old sense of non-military, including in it all branches—mechanical, electrical or mining) the civil or civilian engineering graduate, when he leaves the university with his new degree, plunges into new and strange relations with most of the facts and functions of his life work. West Point is a miniature of the army; Annapolis is a miniature of the navy. But the engineering school is not a miniature of a railroad, of a bridge works, of a construction camp, of a machine-shop, of a power station. The relations to employers and employees are totally unlike the relations to professors and fellow students. Except perhaps in the drafting-room, and to some extent in the laboratory, the problems presented and the attitude toward them have little resemblance to the things made familiar during four years in the class-room.

I offered these remarks in my society paper as introductory to an argument that the methods of technical education might perhaps stand some radical modifications—at least, that they should be searchingly examined to see whether they could not be made

* Remarks at the annual meeting of the Science Alumni Association, 1910.

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to reproduce more nearly the life conditions under which the graduate must work.

Quite recently I repeated this suggestion to a navy man of large recent experience in industrial affairs, and he countered my argument by another. He said: "You are absolutely right as to the military man. There is not the slightest shock or jar in his transition from school to professional work. But you must remember he is specifically destined to do one specific thing. Every one knows exactly what his work will be. He is taught the things necessary to do it. One seldom knows, and indeed it is generally impossible for any one to know accurately, just what the work of a civilian engineering graduate is going to be. So it seems that perhaps all we can do is to prepare him generally for possible employment in any one of several or many ways. He can be only generally adapted to any particular environment—not minutely adapted as the military man is. Hence there will always be some further adaptation necessary, some disturbance during this period of adaptation and transition."

Without waiting, then, for a reply from any advocate wholly committed to the university point of view, we find here a fairly impartial observer accepting the proposition that this difficult and sometimes painful period of adjustment during which the young graduate is finding himself, and orienting himself, and learning to strike out for himself in the strange and turbulent waters into which he is thrown—we find influential opinion that this period is to a considerable extent necessary and inescapable. Even the most radical reformers who would see the conditions, the temper, the discipline, and the routine of the shop incorporated into the organization of the university, would admit that such a change must be gradual, resulting from long years of modification, during which present conditions must continue to prevail wholly or in part.

It is because of this necessary condition—it is during this inevitable period of adjustment, I think—that right relations between the older and the younger graduates are most important. The alumni, rightly organized and inspired, are the strongest force in the whole university. That force can not possibly be better directed than in the wise and healthy coördination of this new, strong, energetic addition that is being made to its body year by year. Its

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function in so doing is especially definite in the case of the applied-science schools, whose older graduates alone have that second point of view of the graduate's life work—the practitioner's point of view—that must supplement the educator's point of view in giving a true, full and properly rounded image.

This is even a larger function than getting the young graduate a job. Important and necessary as it is that he should find a job, the greater requirement still is that he should find himself quickly in that job. The otherwise doubtfully desirable possession of added years and longer experience with men and things helps us to understand better the perplexing problems our younger brethren meet—problems in professional ethics, in personal relations, in the economic and commercial limitations of technical ideals. Our longer affection for the university, our fuller view of the great things that it has done, should strengthen that feeling of relationship and love that we call the university spirit. Our latchstrings should be out, our sympathies quick, our purpose earnest, to impart that spirit, and to share our knowledge of the road with those who tread it behind us. We should take up, outside of the university, so far as we can, the advisory function, so untiringly and so faithfully exercised by the men inside the university. We should coöperate with the authorities and officers of the university to reduce as fast and as far as practicable the tendency on the one hand for teaching to become over-formal, over-scientific, and the tendency on the other hand for practice to become over-commercial.

One great need of the scientific schools today, as I have said before, is freer, very much freer, intercourse between faculty and alumni. In this field, I think, is the great opportunity for service to the oncoming army of the undergraduates, to the university, and to our professions.

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PRACTICAL EXPERIENCE IN MINING.*

By J. PARKE CHANNING.

At a meeting of the Mining and Metallurgical Society of America the other night at the Engineers' Club, the subject of "Proper Instruction for Engineering Graduates and Undergraduates" was under discussion, and Professor Irving, of Yale, said that he thought one of the difficulties which beset young engineers when they graduated was that their point of view was so radically changed when they got into practical life as compared with that same point of view everywhere in the university. As he said, when in the university or the technical school, everything there was done for the young man, everything was arranged for him, and he was the principal object for which the course of instruction was carried on, the buildings, the equipment and the professors being merely incidentals towards an end. When therefore he graduated and got out into practical life, and got his first position, conditions were entirely changed. Instead of things being arranged for him he was of minor importance, and the only consideration shown him was dependent upon what he could do.

I think that his remarks are eminently true. In discussing with you what you should do after graduating I think you should bear this changed condition in mind, and realize that you must give to your employer the very best service that you possibly can, irrespective of what your wage or salary may be.

I have said to the undergraduates before, and I can say it again to you that it is a great mistake to imagine that when you graduate from the School of Mines, or the School of Applied Science and receive your diploma, that you are a finished mechanical engineer, electrical engineer or mining engineer, and as such are capable of reporting upon a property or of managing one. You are only in a position, after you have received say the degree of engineer of mines, to learn the business of mining, and it is a business just as much as banking, or the manufacture of carpets, or the sale of dry

* Remarks at the annual meeting of the Science Alumni Association, 1910.

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goods is a business. The only advantage you have over other men is that you have had a good education, a good training in the fundamentals of your profession. You have been taught how to think, how to investigate subjects, and how to hunt up the particular knowledge which is applicable to the problem before you. You will have received a broad view of the mining and metallurgical field so that when you come to learn things practiaclly, you will be more readily able to determine their relative values, or in other words, to get what is called a sense of proportion.

Mining, like all industries, has become so specialized that it is impossible for a man from practical experience to get enough information to make himself of high standing in the profession. In order to be competent to pass upon the value of a mining property it is not necessary solely to know what the ore runs, and how much of it can be saved, but you will have to know what it will cost to treat the ore and you will not be able to pass upon this question properly, or in fact, upon the best method of treatment, unless you have had actual experience on the operating staff of one or more mines. It therefore is not well for you immediately on graduation to attach yourself to the staff of an examining engineer, and continue with him indefinitely, sampling mines and helping him on his examinations. The sampling and determining of the ore in a mine is, of course, a necessary thing, but it is not everything, and while it would be well for you to do some work of this kind, you should not stay at it too long. You should sceure a position at a mine in almost any capacity which is offered you, either as assayer, surveyor, or if nothing of that kind offers itself, start in underground if you are physically able to, and learn to do some practical underground work. It is not necessary that you be able to earn your living as a miner, but still you should know at least the rudiments of handling the various tools in the ordinary operation of sinking, drifting, stoping and raising, you should know how to put in a set of timber, and above all you should gain some idea as to what a day's work is. In all mining work the question of work per man per day is of great importance.

I think that to a very great extent there is a tendency among young graduates to pay too much attention to the work of equipping a property, and in the treatment of the ore, and not enough atten-

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tion is devoted to the underground work. I think there is a greater future for the young man who will stick to underground work, study it up, and be prepared to introduce improvements and economies in the actual mining of ore. It is only within the last twenty years that the square set method of mining has been gradually going out, and is being replaced by caving methods, or methods in which filling is used. As showing what may be done in this direction Mr. Walter Fitch who was manager of the Champion Iron Mine, at Champion, Mich., told me that the panic of 1893 taught them that the ore could be mined for just one half what it cost them before the panic, and that the men got just as good a wage.

So, therefore, I tell you that when you graduate get a position at a mine or in a mine, irrespective of what your wages are, work just as hard as you can at it, and realize that it is going to take you at a minimum five years of varying positions at a mine, underground and on surface before you are competent to act as manager.

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METALLURGICAL ABSTRACTS.

By WILLIAM CAMPBELL.

Copper.

Wallaroo and Moonta Copper Mines and Smeltery: G. W. Williams. *E. and M. J.*, 1909, 88, 55. The Wallaroo mines and methods, Moonta mine, concentration, cementation of tailings and precipitation on scrap iron at cost of 9 c. a lb. of tough pitch metal. Smelting and refining plants on Wallaroo Bay. Ore roasted in brick cells, acid works. Fines are pot roasted. 2 blast furnaces make 45 to 50 per cent. matte. Slag granulated. Matte is "bottomed" in reverberatories, 8 per cent. Cu acting as silver and gold collector. Regulus brought to tough copper in another set of furnaces and then sent to refinery. The "bottoms" and roaster slags are treated in the "foul copper" department. A rough copper produced by melting the slag and roasting the matte so obtained, is melted with the bottoms and cast in anodes and refined electrolytically. Refinery mud boiled with sulphuric acid and smelted with lead, cupel and part electrolytically. Flue dust treated with acid and sulphate sold. Reverberatory, electrolytic and cement copper refined and cast as Wallaroo Tough Pitch. Costs given.

Electrolytic Refining of Copper: G. H. Blackmore. *M. and Mins.*, 30, 1910, 648, 746. From a paper in *Proc. Aust. Inst. M. E.*, Feb., 1910, on the electrolytic refining of auriferous and argentiferous copper at Lithgow, N. S. W.

Michigan Copper Mines and Methods: B. R. Brinsmade. *Min. Wld.*, 32, 1910, 831. The Calumet and Hecla smelter on Torch Lake. The Osceola, Tamarack, Isle Royale and allies use works of the Lake Superior Smelting Co., on Dollar Bay. The Franklin, Centennial, Allouey, Mass and Adventure mines smelt at the Handcock Plant in Handcock. The Atlantic, Baltic, Champion, Michigan, Mohawk and Wolverine copper goes to the Michigan Smelting Co., near Houghton. Older practise, 15- to 40-ton reverberatory, charge includes 15 per cent. of slag from refining operation and 4–6 per cent. limestone. Air blowing till oxidized, then refined by poling. Copper containing 60 ozs. or more Ag cast into anodes. Rest into merchant form. Slag treated in blast furnaces. Michigan Smelting Works, 2 melters 18 × 35 ft., the other 15 × 30 ft. Three refining furnaces 13½ × 23 ft. hearths. Walker casting machine. 48 × 120 in. blast furnace for slags. The Tamarack-Osceola smelter has wire and sheet plant.

The Vermont Copper Company: A. H. Fay. *E. and M. J.*, 1909, 88, 364. Situated 2 miles east of S. Strafford, Orange Co. First worked in 1793. Ore pyrrhotite with fine chalcopyrite. A 16 × 44 in. furnace has been erected.

Copper Mines and Smelteries of Shasta County: G. A. Packard.

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E. and M. J., 1909, 88, 393. Topography. Ores. Mountain Copper Co. Smelters at Keswick and at Martinez on San Francisco Bay. Balaklala smelter at Coram. Mammoth smelter at Kennet. Bully Hill Co.'s smelter near the Mammoth.

International Smelting and Refining Co.'s Plant: L. A. Palmer. *Min. Wld.*, 32, 1910, 419. Construction of the Tooele smelter. To smelt 1,200 tons from Utah Con. which comes over the mountain from Bingham by aërial tramway. 32 McDougal roasters, 5 reverberatories 19 × 102 ft., 5 Leghorn converters 96 × 150 in.

The Concentrator of the Ohio Copper Co.: L. A. Palmer. *Min. Wld.*, 32, 1910, 49. Located at Lark, Utah. Started Nov., 1909. Jigs and tables with a few buddles used. Description of the mill with photographs.

The Balaklala Mine and Smelter, California: A. H. Martin. *Min. Wld.*, 32, 1910, 1163. Comprises 3 blast furnaces, 4 McDougal roasters, a reverberatory and a converter plant.

The Steptoe Concentrating Plant, Nevada: L. A. Palmer. *Min. Wld.*, 32, 1910, 599. Plant at McGill for Nevada Con. and Cumberland Ely Ore. Wilfley tables and Johnson vanners. Huntington mills and Garfield Chilian mills for regrinding. Illustrations.

The Steptoe Smelting Plant, Nevada: L. A. Palmer. *Min. Wld.*, 32, 1910, 691. 16 McDougals, 4 reverberatories 19 × 112 ft., 250 tons a day each. 10 per cent. limerock as flux. 45 per cent. matte. Slag SiO_2 40–45 per cent., CaO 6–12 per cent., Al_2O_3 4 per cent., Fe 40–73 per cent. New blast furnace 42 × 240 in., at tuyeres. Four 96 × 150 in. converters, total capacity 100 tons blister a day.

Concentration at the Butte Reduction Works: A. H. Wethey. *E. and M. J.*, 1909, 88, 415. A custom smelter. Flow sheet of 500-ton concentrator given. Blake crusher. Wood separator. Trommels and rolls. Jigs. Slime tables, etc. Monadnock mills and Wilfleys.

Smelting Plant of the Butte Reduction Works: A. H. Wethey. *E. and M. J.*, 1909, 88, 1153. Two blast furnaces 42 × 124 in. Five Wethey roasters and 2 MacDougalls. Reverberatory matting furnaces 80 × 20 ft. 3 converter stands electrically operated. Reinforced slag construction of culverts. Plan of works.

Copper Blast Furnace Smelting at Anaconda: C. Offerhaus. *E. and M. J.*, 1909, 88, 243. Two furnaces 51 ft. with two crucibles and two settlers. One 87 ft. furnace with 3 crucibles and 3 settlers. Plan to increase length 50 ft. These replace or are built out of the seven 15 ft. × 56 in. furnaces. Description of smelting, calculation of charge, etc. Excellent illustrations.

The Granby Smelter Equipment: B. L. Sackett. *M. and Mins.*, 30, 1910, 525. 4,000 to 5,000 tons ore average 1¼ per cent. copper smelted daily. Plan of smelter. 8 blast furnaces. Converters. Flue dust and briquetting plant.

Smelting Practice of the Tyee Copper Company: G. W. Maynard. *E. and M. J.*, 1909, 88, 905. Smelter situated on Oyster Harbor, Vancouver Is. Sampling mill described. 40 × 120 in. furnace, 225–275 tons a day. 40–45 per cent. matte. Slag granulated. Slag

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45.7 SiO_2: 19.8 FeO: 21.1 CaO: 7.07 MgO: 6.55 Al_2O_3. Influence of barytes in the charge. Fluidity of slag and easy separation of matte results. Analyses of ores given.

New Copper Blast Furnaces at Tezuitlan Smeltery: C. Robinson. *E. and M. J.*, 1909, 88, 655. Description of the Robinson copper blast furnaces. Illustrations.

Cananea Ore-bedding System: R. L. Herrick. *M. and Mins.*, 30, 1909, 65. Description and photographs of ore beds. The smelter capacity is 3,000 tons a day. A single bed is 8,000 tons.

Methods of Analysis at Cananea Con. Property: E. W. Buskett. *Min. Wld.*, 32, 1910, 703. Gives methods of routine analyses of slags, ores, bullion, etc., at the Ronquillo laboratory.

The Cerro de Pasco Smelting Works, Peru: L. W. Strauss. *Min. Wld.*, 32, 1910, 709. Smelter at Tinyahuarco, port of Callao. Analyses of ores. 3 B. F. 56 × 180 in. and one 50 × 180 in. Analyses of slags, mattes, dust, etc. 2 McDougals and one reverberatory for fines, etc. Four 10-ton converters.

Modern Type of the Barrel Copper Converter: C. F. Shelby. *E. and M. J.*, 1909, 88, 815. Illustrated description of barrel and ball types.

High Silica Slags at the Magistral Smelter: C. A. Heberlein. *E. and M. J.*, 1909, 88, 107, 177. Smelter at Zacatecas, Mex. 46 × 150 in. furnace. SiO_2 50 per cent., CaO 22 per cent., FeO 20 per cent. Matte fall 5.5 to 5.8 per cent., blast 32 to 34 oz. Comparison of Mansfeld and Magistral slags. The bi-silicate slag.

The Nickel-Copper Industry of Ontario: Alex. Gray. *Min. Wld.*, 32, 1910, 973, 1019, 1065. Index map of area. Historical. Discovery of the Oxford nickel process. Organization of the International Nickel Co. Growth of use of nickel in alloy steel, etc. Mining. Metallurgy. Heap roasting. Smelting and converting. Refining at Orford. The silver plant at Copper Cliff for treating cobalt ores. Roast off arsenic, then blast furnace yield metallic silver and speiss.

Behavior of Copper-Matte and Copper-Nickel Matte in the Bessemer Converter: D. H. Browne. *Bull. 40, A. I. M. E.*, 1910, 285. Found that nickel is not an element replacing iron in matte, nickel-copper alloys act in the matte-blow like one metal and follow the same laws as govern copper alone.

Gold and Silver.

Review of Modern Cyanide Practice in United States and Mexico: S. F. Shaw. *Bull. A. I. M. E.*, 31, 1909, 591. A review of the principal details of practice during 1908. Combination, Goldfield; Desert, Millers; Dos Estrellas; El Oro; El Rayo, Sta. Barbara, Chili; Goldfield Con.; Pinguico, Guanajuato; Homestake; Loretto, Pachuca; Montana-Tonapah; North Star, Grass Valley; Palmarejo, Chili; San Prospero, Guanajuato; San Francisco, Pachuca; Standard, Bodie; Veta Colorado, Parral.

The Cyaniding of Silver-Ores in Mexico: A. F. Bordeaux. *Bull, 37, A. I. M. E.*, 1910, 51. General plan, stamps then Huntington or

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Chilean mills to 80-mesh, vanners, separation of slimes by spitzkasten or cones, slime in tube-mill to 100–120-mesh. Slime treatment by decantation.

Improvement in Cyanide Practice: E. G. Spilsbury. *Bull. 41, A. I. M. E.*, 1910, 353. All sliming. Pachuca tank. The silica sponge diaphragm used in treatment tanks, also in filtering solutions in table or wheel form. Appendix of experimental tests at San Matias mill, Guanajuato.

Cyanide Practice at Minas del Tajo Mexico: Tweedy and Beals. *Bull. 38, A. I. M. E.*, 1910, 123. Cyanidation replaced pan-amalgamation. Details of tests, mill and method. Oliver filters. Cost sheets.

The Silver Cyanide Mill of the San Rafael y Anexas Co., Pachuca: E. Girault. *Met. and Chem. Eng.*, 1910, VIII., 124. Plan of plant with clear, detailed description. Résumé giving assays, extractions and costs.

San José de Gracia, a Great Mexican Gold Camp: E. A. H. Tays. *E. and M. J.*, 1909, 88, 640. Historical. 90 years' continuous production of bonanza ore. Anglo-Mexican Co., Sinaloa.

Operations of Guanajuato Development Co. E. and M. J., 1909, 88, 651. Revenue and profits. Cyanidation of concentrates, Pinguico Mines and Mill. Peregrina Co. Milling and Transportation Co.

An All Slime Cyanide Plant at Guanajuato: E. Shapley. *E. and M. J.*, 1909, 88, 68. Santa Natalia Co. Ten-stamp mill. Tube mill. 10 hrs. agitation in treatment tanks. Decanted to filters. Zinc box precipitation.

Ore Treatment at the Virginia and Mexico Mill, Jalisco, Mexico: J. Scobey. *E. and M. J.*, 1909, 88, 686. 3 Blake rock breakers. Bins. 6 batteries of 30 stamps, 12-mesh. Six Wilfleys. Sands to two Allis-Chalmers 42 × 16 ft. tube-mills. 6 additional Wilfleys. Sand plant with Butters distributers, etc. Slimes plant, settling tank, fourteen 15 × 22 ft. slime tanks with air agitation and decanting. Butters storage tank, filter, clarifying tanks. Six 8-compartment zinc boxes.

Tube-Mill Circuit and Classification: G. O. Smart. *Jl. Chem. Met. and M. Soc. S. Africa*, X., 1910, 282. Describes use of single cone with large outlet at bottom for each tube-mill. Work at Simmer and Jack, pyramidal spitzlutten and dewatering cones versus single cone classifiers with diaphragms.

Continuous Collection of Sand for Cyaniding: W. A. Caldecott. *Jl. Chem. Met. and M. S. S. Africa*, X., 1909, 43. Description of slowly rotating horizontal filter for continuously removing the water and slime from the tailings pulp so as to leave the sand in proper condition for cyanide treatment. Work at the Simmer and Jack. Photographs and diagrams. Costs.

Handling Tailings at Colorado City: R. L. Herrick. *M. and Mins.*, 30, 1910, 621. Methods at Standard, Golden Cycle and Portland mills.

Dry Chlorination of Sulphide Ores: H. J. Wolf. *West. Chem. and Met.*, VI., 1910, 176. Gives a short review of early processes and describes the Malm process, method, reactions and results obtained.

The Design of a Dry Chlorination Plant: McCallum and Bruderlin.

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West. Chem. and Met., VI., 1910, 206. A graduation thesis from Colorado School of Mines.

The Silver Mining Camp of Cobalt, Ontario, Canada: H. B. Hallowell. *West. Chem. and Met.*, VI., 1910, 89. Gives a general idea of methods of prospecting, mining, concentrating, metallurgy.

The Assay and Valuation of Gold-Bullion: F. P. Dewey. *Bull. A. I. M. E.*, 32, 1909, 705. Describes an investigation to establish the reasonable differences in the assay-results at the various offices of Bureau of the Mint, which may be commercially allowable in the settlements between them.

Fuel.

Genesis and Development of the Coking Oven: W. Galloway. *E. and M. J.*, 1909, 88, 11. Describes early method of stacking coal in a circular pile, the oblong pile, the first ovens, early type of oven for recovery of volatile products, the Pernolet oven.

Pyrometry of the Beehive Coke Oven: J. R. Campbell. *E. and M. J.*, 1909, 88, 120. Various pyrometers mentioned. In a 48-hr. charge temperature at 3 hr. = 2110° F., 18 hr. = 2765° F., 27 hr. = 2800° F., 33 hr. = 2725° F., 45 hr. = 2370° F. Other figures given.

The Mexican Coke Industry: R. D. Martin. *M. and Mins.*, 30, 1909, 129. Sabinas, Coahuila, the center of the coke district. Ovens of beehive type. Drawings to scale.

The Construction of Gas Producers: O. Nagel. *El. and Met. Ind.*, 1909, VII., 393. Describes and illustrates various producers such as Siemens, Ebelman, Buire-Lencanchez, Zetzsche, Waterseal with Bildt feed, Morgan, Poetter, Taylor, Hughes, Frazer-Talbot, etc.

Iron and Steel.

Some Experiments on Smelting Titaniferous Iron Ore: G. H. Stanley. *J. Chem, Met. and M. S. S. Africa*, XI., 1909, 162; 1910, 345. Ore from Onderstepoort containing 15 per cent. TiO_2. Charges run in clay pot to 1400–1600° C. The more basic mixtures made the best slags so far as iron yield. Experiments on slags, proportion representing sphene CaO, TiO_2, SiO_2 heated to 1400° C. Yielded brown sub-translucent glass. Other proportions less fusible. Titanium exists in slags as Ti_2O_3 which acts as a base when sufficient silica is present. Table of tests given, showing charges, slag analysis, yield of iron, slag and temperature.

Blast furnace experiments in one of Thwaite's Rapid Cupolas, hearth 22 in., 12 ft. column, yielded well fusible slags but generally a sow of soft iron.

The Attainment of Highest Purity on a Commercial Basis: J. A. Aupperle. *Met. and Chem. Eng.*, 1910, VIII., 262. American ingot iron manufactured by American Rolling Mill Co., Middletown, Ohio. Basic open hearth used. Deoxidation and degasification completed in ladle by aluminium. Analysis given is C = 0.01, Mn = 0.003, Si = 0.002, S = 0.015, P = 0.001, O = 0.012. Tests on corrosion given.

État actuel du Procédé d' Affinage sur Sole: O. Petersen. *Rev. de*

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Met., 7, 1910, 197. Work at the following plants: Hoesch, Westhalia, Hubertushutte, Julienhutte, Upper Silesia, Bethlen-Falvahutte, Donawitz, Jurjewka, Zawiercie, Czentstochan, Illinois Steel Co., Witkowitz, Monterey, Ensley, Yawatamachi, Hüsten, Georgsmarienhütte. The Talbot process at Cargo Fleet.

Manufacture of Armor-plate by the Krupp Process: W. F. Gregoretti. *Rev. de Met., 7,* 1910, 260. Steel used, Ni 3.9 per cent., Cr 1.78 per cent., C = 0.31 per cent. Open hearth ingot cooled to 500° C., reheated for 12 hrs. to 1200° C. Rolled and planed. Cemented at 850 to 900° C. for 7 to 20 days by illuminating gas. Quenched from 800 to 850° C. in olive oil. Reheat to 660° and quenched in water, which develops fibrous structure. Illustrations of plant at Terni, Italy. Micrographic study of structures produced. Tests employed.

On Cementation by Carbon: Guillet and Griffith. *Rev. de Met.,* 1909, 6, 1013. No cementation unless the carbon is in contact with the metal. With increase in pressure the cementation increases. Dissolved gases effect the results.

Contribution to the Study of Steels for Speed-Change Gears: L. Revillon. *Rev. de Met.,* 6, 1909, 1024. Discussion of characteristics sought. Analyses of steels, mostly nickel or nickel-chrome, used. Effects of heat treatment, quenching and tempering.

Electric Smelting with the Girod Furnace: W. Borchers. *E. and M. J.,* 88, 1909, 1113. Description and illustrations of 12-ton furnace; the 2½-ton furnace. The old plant at Ugine and the new steel works. A list of users of the Girod furnace is given.

The Girod Electric Furnace: W. Borchers. *Bull. 37, A. I. M. E.,* 1910, 1.

South Chicago Electric Furnace Plant of U. S. Steel Corporation. Met. and Chem. Eng., 1910, VIII., 179. At S. Chicago the electric furnace is used for refining molten metal from the Bessemer converter, at Worcester for refining basic open hearth steel. Description and photographs of the Héroult furnace. Record of operation.

Manufacture and Transport of Ferrosilicon: Monckton, Bennett and Hake. *Met. and Chem. Eng.,* 1910, VIII., 133. British Local Govt. Board yellow book. Gives the metallurgy and process of manufacture. Specific gravity, constitution. Transport and storage. Dangerous grades are 30–40 per cent. and 47 to 65 per cent.

Lead.

Silver-Lead Mines of Bandwin, Shan States: T. D. La Touche and J. C. Brown. *E. and M. J.,* 1909, 88, 550. Geology. Ores. Mines. Chinese methods of treating the ores. Illustrations of the old smelting and cupel furnaces. About 125,000 tons of rich slags.

The Concentration of Silver-Lead Ores at the Works of Block 10 Co., Broken Hill, N. S. W.: V. F. S. Low. *Bull. A. I. M. E.,* 33, 1909, 763. Detailed description with flow sheet. Rolls, trommels, coarse jigs, ball mills, classifiers, fine jigs, Wilfleys, grinding pans, Card tables, vanners, etc.

Smelting Refractory Lead Ores at Laurium: L. Guillaume. *E. and*

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M. J., 1909, 88, 446. Describes the old method. New American furnace. Slag—25 per cent. SiO_2, 23 per cent. Fe, 17 per cent. CaO, 11 per cent. Al_2O_3, 9.9 per cent. Zn. Matte—40 per cent. Fe, 12.7 per cent. Zn, 11 per cent. Pb, 20 per cent. S. Speiss—50 per cent. Fe, 3 per cent. Pb, 33 per cent. As, 150 gms. Ag.

Elimination of Smelter Fume: L. A. Palmer. *M. and Mins.*, 30, 1910, 496. Description of roasting methods of the U. S. Smelting Co. at Bingham Junction. 19 pot roasters for ore, 5 reverberatories $60 \times 18 \times 6$ ft. Fume neutralized by zinc oxide to zinc sulphate. Baghouse. Arsenic plant with two Brunton arsenic furnaces and refining furnace.

Midvale Blast Furnace Practice: L. A. Palmer. *M. and Mins.*, 30, 1910, 543. Description. 6 lead furnaces. Kilker moulding machine for matte. Matte enriched from 40 per cent. to white metal in reverberatory and shipped to Chrome, N. J.

Arsenic Manufacture at Midvale: L. A. Palmer. *M. and Mins.*, 30, 1910, 641. Plant of U. S. Smelting Co., Utah. Description of the Brunton arsenic furnace and the refining reverberatory.

Wet Concentration at Midvale: L. A. Palmer. *M. and Mins.*, 30, 1910, 517.

Zinc, Mercury, Etc.

Elmore Process as Applied by Zinc Corporation. E. and M. J., 1909, 88, 205. Illustrations, flow sheets and description of works and method. Treatment cost total 5s. 7.08d. per ton.

Shortening the Roasting Period for Mercury Ores: W. B. Dennis. *E. and M. J.*, 1909, 88, 112. Illustration and description of working of the Dennis roasting furnace which reduces the time from 24 to 4 hours.

Uranium and Vanadium Metallurgy: J. H. Haynes. *M. and Mins.*, 30, 1909, 139. Gives diagram of process for reducing vanadium and uranium from carnotite. Description of various processes. Crushing. Roasting. Agitate with Sod. Carbonate. Precipitate $Na_2O.3UO_3$ by Sod. hydrate, then $Ca_3(VO_4)_2$ by lime.

General.

Modern Progress in Mining and Metallurgy in the Western United States: D. W. Brunton. *Bull. A. I. M. E.*, 33, 1909, 837. A general paper showing latest development from mine-mapping to fume-recovery.

Mining and Metallurgy in Chili: F. A. Sundt. *M. and Mins.*, 30, 1910, 646. General synopsis of the industries.

Modern Practice of Ore-Sampling: D. W. Brunton. *Bull. A. I. M. E.*, 32, 1909, 675. Discussion of methods. Sections of Taylor-Brunton sampling mill, Silver City, Utah; matte and sulphide mill of Tintic Smelting Co. Flow sheets and Section of Western Ore-purchasing Co., Millers, Nev.; A. S. and R. Murray; examples of work done.

The New Ore Dressing and Metallurgical Plant of the Colorado School of Mines: F. W. Traphagen. *West. Chem. and Met.*, V., 1909,

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361. Plan and description of mill. Composed of units each independent. Approximate capacity 50 tons per 24 hrs. Crushing. Sampling. Stamp mill. Roll crushing. Classifier and concentrating. Dry concentration units. Cyanide unit 5 tons capacity. Smelting unit has hand reverberatory 4′ × 9′. Cupelling furnace. 18″ × 36″ blast furnace. Laboratory unit.

Ore-dressing in the U. S. and Mexico: H. A. Guess. *E. and M. J.*, 1909, 88, 864, 966. Principal processes grouped as (1) Amalgamation, (2) cyaniding, (3) water concentration, (4) miscellaneous. Flow sheets of Boston and Montana, Greene-Cananea, Mace no. 2 of Federal M. and S. Co., Idaho; Boston Con. Mill at Garfield; Silver Lake at Silverton; Cumberland, Ely; Grace Zinc Co.; Federal Lead Co., no. 3, Flat River; Minas Tecolotes y Anexas.

Recent Progress in Blast-Roasting: H. O. Hofman. *Bull. 42, A. I. M. E.*, 1910, 473. Pot roasting, up-draft. Down-draft, drum or straight line. Lloyd-Dwight machines. The horizontal-table machine, Garfield.

Notes on Ore-Roasting: J. E. Edwards. *West. Chem. and Met.*, VI., 1910, 48. General paper on ore-roasting.

Cementation: A. Sang. *El. and Met. Ind.*, 1909, VII., 485. Gives the theories of cementation of iron with carbon. Electric-cementation. Dry galvanizing or cementing, Berry and other methods. Present-day methods. Diffusion with and without pressure.

Copper-Clad Steel: Wirt Tassin. *E. and M. J.*, 1909, 88, 813. Steel billets sandblasted and pickled. Heated to red. Placed in a hot tube which forms walls of the mould. Billet dipped in copper in supermolten condition and coated, replaced in the tube, and whole immersed in copper bath, till tube is full. Withdrawn and when copper is solid the tube is rammed off. Rolled down in usual way. Has unusual strength.

Inoxidation Processes for Protection of Iron and Steel: A. Sang. *El. and Met. Ind.*, 1909, VII., 351. Describes the Barff, Bower and Bower-Barffing processes, also the Gesner, Wood, Hydrœsfer and electric processes.

Conductivity, Porosity and Gas Permeability of Refractory Materials: S. Wologdine and A. L. Queaeau. *El. and Met. Ind.*, 1909, VII., 383. Describes apparatus for determining heat conductivity and results obtained on various materials up to 1000° C. The main factor is the temperature of burning and not so much the character of the material. Silica brick has coefficient only half that of clay brick. Apparatus for determining permeability, and results. Graphite crucibles impervious.

Investments from an Engineer's Standpoint: J. P. E. Channing. *Min. Wld.*, 32, 1910, 271. Address to the Finance Forum, N. Y. Cost of ton of pig in N. Y. is $12.50. With a selling price of $16.50, a profit of $4 a ton. Copper cost to produce from 7½ to 12½ cts. The price fluctuates from 11 to 25 cts., averaging 14 to 15 cts. Disseminated ore bodies now prominent. Silver mines sell cheaper because

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life is usually shorter. Discusses value of shares in relation to dividends and life of mine. The value of mines is the metal in them.

METALLOGRAPHY, ETC.

The Organization of Some German and Belgian Laboratories: G. Arnon. *Rev. de Met.*, 7, 1910, 405. Study of some iron and steel laboratories. Microscopic equipment, analysis, uses of Brinell and shock tests, by Charpy, Guillery or Frement machines.

On the Hardness Test by the Ludwik Method: E. Meyer. *Zeits. des ver. deut. Ing.*, LII., 740, 2077 (1908). Abs. *Rev. de Met.*, 6, 1909, 467. A conical point is pressed into the metal to be tested and depth measured under a certain load. There is a lip of metal raised and the work was to determine relation of real to apparent depth of impression.

Metallographic Study of Slags of Iron and Steel: Mat Weieff. *Rev. de Met.*, 7, 1910, 447. Has worked out a method of distinguishing between silicates, oxides and sulphides of iron and of manganese in the microsection. Uses hydrogen, superheated steam, organic acids.

Microscopic Examination of Some Cast Irons: J. Guillemin. *Rev. de Met.*, 6, 1909, 946. Specimens contained 0.5 to 0.65 per cent. combined carbon and about 3.5 per cent. total carbon. Experiments in annealing, quenching and tempering at 400° C. Annealing or quenching and reheating gives the least brittleness. Temperature 900° C. the best for both.

On the Structure of Steel at High Temperatures: Baykoff. *Rev. de Met.*, 6, 1909, 829. Polished specimens heated in hydrogen to desired temperature, then pass in HCl to etch specimens. Austenitic structure, never martensite, obtained. Martensite due to mechanical deformations produced during quenching.

Influence of Temperature on Mechanical Properties. El. and Met. Ind., 1909, VII., 455. Abstract of paper by Rudeloff, congress of Society for Testing Materials. Wrought iron increases in tensile strength up to 250° C. Similarly soft Bessemer. Open hearth (0.2 per cent. C.) shows maximum at 200° C. Cast iron unimpaired up to 400° C.; loses 60 per cent. at 600° C.

ALLOYS.

A Brass Foundry in a Steel Mill. Met. Ind., 1909, 363. Illustrations of Bethlehem Steel Co.'s foundry. 14 pit furnaces, new five-ton reverberatory.

The Manufacture of Wrought Brass: L. J. Krom. *Met. Ind.*, 1910, 8, 111, 157. Gives the various mixtures of the trade and their uses. Brasses containing lead, those with tin. The casting shop. Evolution of brass castings, the mixture, preparing moulds.

Laiton a Cartouches. Laiton a Balles. Cuivre Electrolytique: Capt. Grard. *Rev. de Met.*, 6, 1909, 1069. Brasses were 67/33 and 90/10. Effects of annealing on physical properties and microstructure. Brass of 6 mm. thick annealed at 700 to 750° C. Electrolytic copper anneals at 400 to 700° C. Ranges given.

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Volume Changes of Brasses During Solidification: M. T. Murray. *Jl. Inst. Metals,* II., 1909, 101. Description and illustration of extensometer used. Curve for the series worked out. Total shrinkage. Hardness by scleroscope and Brinell methods. The Shepherd and the Tafel diagrams are shown together with a number of photomicrographs.

Copper-Tin Alloys: Gioletti and Tavanti. *Gazetta Chimica Italiania,* 38, 1908, 1–31. Abs. *Rev. de Met.,* 6, 1909, 476. Results between 62 and 77 per cent. Cu differ from previous workers. Eutectic at 6 per cent. Cu.

Modern Bronzes: A. H. Hiorns. *Met. Ind.,* 1910, 19, 82. Discusses the copper-tin alloys. The effects of quenching. Composition and color. Bronzes for various uses. Special bronzes, lead-, phosphor-, manganese-, and silicon-bronze. Aluminium bronze.

Modern Bronzes: C. Vickers. *Met. Ind.,* 1909, 7, 255. Discusses properties due to addition of Al, Si, Mg, P, Mn and Fe.

Bronzes Containing Zinc: Guillet and Revillon. *Rev. de Met.,* 7, 1910. 429. Determination of coefficient of equivalence of zinc in bronze which is less than 0.1. Physical properties of the various specimens given.

Notes on Phosphor Bronze: A. Philip. *Jl. Inst. Metals,* I, 1909, 165. Divisions of drawn, rolled or forged; small castings; bearings; sheaves; gear wheels, etc. Castings should be Cu 90–92 per cent., Sn 7.4–9.7 per cent., P 0.3–0.6 per cent., to give tensile strength of 17 tons per sq. in. and elongation in 2 in. of not less than 20 per cent. Alloys with over 0.7 per cent. P studied. Several pages of tests are given showing uses, analyses, physical properties, etc.

Phosphor Bronze: O. F. Hudson and E. F. Law. *El. and Met. Ind.* (*Met. and Chem. Eng.*), VIII., 1910, 95 (abs). Paper presented to Institute of Metals. Ternary eutectic contains 81 per cent. Cu, 14.2 per cent. Sn and 4.8 per cent. P and melts at 620° C. With less than 4.5 per cent. Sn slowly cooled alloys consist of copper holding tin in solution and of copper phosphide in rather large masses. With more than 4.5 per cent. Sn the ternary eutectic appears.

Copper-Arsenic Alloys: Bengough and Hill. *Met. and Chem. Eng.,* VIII., 1910, 95. Abstract of paper before Institute of Metals. Deals with mechanical properties of the alloys of industrial importance and with their chemical constitution.

The Transformation-points of the Copper-Aluminium Alloys (8 to 15½ per cent. Al). M. Barrée. *Rev. de Met.,* 7, 1910, 16. Study of variation of electric resistance with temperature. Three transformation-points: about 200° C., about 500 and about 750° C. Temperatures on heating higher than those on cooling.

The Constitution and Properties of the Aluminium-Copper-Tin Alloys: C. A. Edwards and J. H. Andrews. *Jl. Inst. Metals,* II., 1909. 29. The ternary diagram has been worked out. No ternary compound is formed, no ternary eutectic. Useful alloys confined to two very limited areas, the copper rich, and the aluminium rich.

Alloys of Silicon: A. Portevin. *Rev. de Met.,* 6, 1909, 951. Con-

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tinuation of translations from *Zeit. an Chem.*, mostly from works in Tammann's laboratories. Alloys of Al, Bi, Ca, Co, Mg, Mn, Sn, Pb, Tl.

Alloys of Tin. Same. Ca, Co, Cr, K, Na, Pt.

Alloys of Zinc. Same. Ca, Cd, Co, Cr, K, Na, Tl.

Physical Properties of Monel Metal in Comparison With Manganese Bronze and Steel: C. S. Dunbar. *Met. Ind.*, 1909, 327.

	Manganese Bronze.	Monel Metal.	Nickel Steel.
Elastic limit.....	46,200 lbs. per sq. in.	76,500 lbs.	81,100 lbs.
Max. strength.....	80,600 " " "	105,500 lbs.	107,700 lbs.
Elong. in 2 in.....	26 per cent.	19.5 per cent.	21.5 per cent.

Under alternate stress tests monel metal almost equal to nickel steel which contained Ni 3½ per cent., C 0.35 per cent., Mn 0.48 per cent.

The Mechanism of Annealing in the Case of Certain Copper Alloys: Bengough and Hudson. *Jl. Inst. Metals,* I, 1909, 89. Discussion of term "annealing." Cause of hardness under work. Annealing of brass at 600 to 650° C. Muntz metal most ductile after annealing at 550–600° C. Aluminium bronze. True bronze.

Some Physical Characteristics of Iron Alloys: C. F. Burgess and J. Aston. *El. and Met. Ind.*, 1909, VII., 436. Gives a summary of forging, welding and machining properties of electrolytic iron and its carbon-free alloys.

Notes on Some Probable Causes of Corrosion of Copper and Brass: E. L. Rhead. *Jl. Inst. Metals,* 1909, II., 73. Gives the more common cases of corrosion, tubes of surface condensers, Muntz metal sheathing, etc., brazing alloy in copper pipes, propellers, locomotive boiler tubes, sheet copper subject to action of fire gases. Experiments made in solutions of ferric chloride and in other solutions. Soft and hard brass. Hard metal corrodes faster than soft.

On the Thermo-Electric Properties of Alloys: W. Broniewski. *Rev. de Met.*, 7 1910, 341. Gives the curves for a number of alloys. A bibliography with title and alloys used, 1822 to 1909. Seebeck to the recent work Pushin and others.

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BOOK REVIEWS.

Metallography. By CECIL H. DESCH, D.Sc. (Lond.), Ph.D. (Wurzb.), Graham Young Lecturer in Metallurgical Chemistry in the University of Glasgow. Crown 8vo. 9s. Longmans, Green, and Co.

This book is divided into eighteen chapters which deal with the following headings: Introduction; The Diagram of Thermal Equilibrium; Solid Solutions or Mixed Crystals; Ternary and More Complex Systems; Metals which are only Partially Miscible in the Liquid State; Practical Pyrometry and Thermal Analysis; The Preparation of Micro-Sections; The Microscopical Examination of Prepared Sections; The Crystallization of Metals and Alloys; Undercooling and the Metastable State; Diffusion in the Solid State; The Physical Properties of Alloys; Density,—Thermal Expansibility—Hardness—Electrical Conductivity—Thermo-Electric Power—Magnetic Properties; Electromotive Force and Corrosion; The Construction of the Equilibrium Diagram; The Molecular Condition of Metals in Alloys and the Nature of Inter-Metallic Compounds; The Plastic Deformation of Metals and Alloys; The Metallography of Iron and Steel; The Metallography of Industrial Alloys.

The book sets forth very clearly our present knowledge of metallography which is defined as a study of the internal structure of metals and alloys and of its relation to their composition and to their physical and mechanical properties. As it is one of the text books of physical chemistry edited by Sir William Ramsay, it naturally takes up the study from that standpoint.

Starting with the diagram of thermal equilibrium, the basis of which is the freezing point curve, the author, by clear steps, works out the different cases and merely touches upon the phase rule and shows its application to alloys. The discussion of the ternary systems is exceedingly well written. Under the heading of Practical Pyrometry and Thermal Analysis we have given us in forty pages, a condensation of the methods in use and the instruments for the autographic registration of curves. It would seem to us that this chapter was rather too condensed for the ordinary student; however, the references given cover the subject very thoroughly. The chapter on the Crystallization of Metals and Alloys is exceedingly well written and the microphotographs illustrating it are very happily chosen. The chapter on the Physical Properties of Alloys, covering density, thermal expansion, hardness, conductivity, etc., covers the ground very thoroughly and we can gather a very clear idea of what has been done and what remains to be done on this side of the subject. The later part of the book, dealing with the metallography of iron and steel, summarizes in a very few words our present knowledge of the subject and the book ends with an appendix consisting of tables of systems of which

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equilibrium diagrams have been published, the probable formulæ of inter-metallic compounds present have been added. The table is divided into eutectiferous series, isomorphous series, the metals only partially soluble in liquid state; series forming a single compound, complex series in which two or more compounds are formed, and systems which have not been completely investigated and lastly the ternary systems.

On reading through this book, one is immediately struck by the feeling that Mr. Desch is familiar with his subject from the practical standpoint and not merely from reading the researches of others. He speaks with authority and therefore what he says is convincing. In addition, the style is so straight-forward and simple that the book will be found both instructive and fascinating, not only to students, but also to practitioners who are interested in metallurgy in general, and alloys in particular. The book covers a very wide field but covers it well, and Mr. Desch is to be congratulated in supplying a long-felt need because there is no doubt that to-day metallography has become quite an important branch of study.

W. C.

An Introduction to Physical Science. By FREDERICK H. GETMAN. 12mo, v + 257 pages, 129 Figures. New York, John Wiley & Sons. $1.50.

The object of this book is to present those portions of physics which are most important for the student of chemistry if he is to fully and properly appreciate his course in general chemistry. It can be said that the author has accomplished his aim in a very satisfactory manner, and that the book should be very useful indeed, not only as directly intended, but also as a reference book for those who are taking general chemical courses and find their lack of knowledge of physics a handicap; a thing which unfortunately has always been too common.

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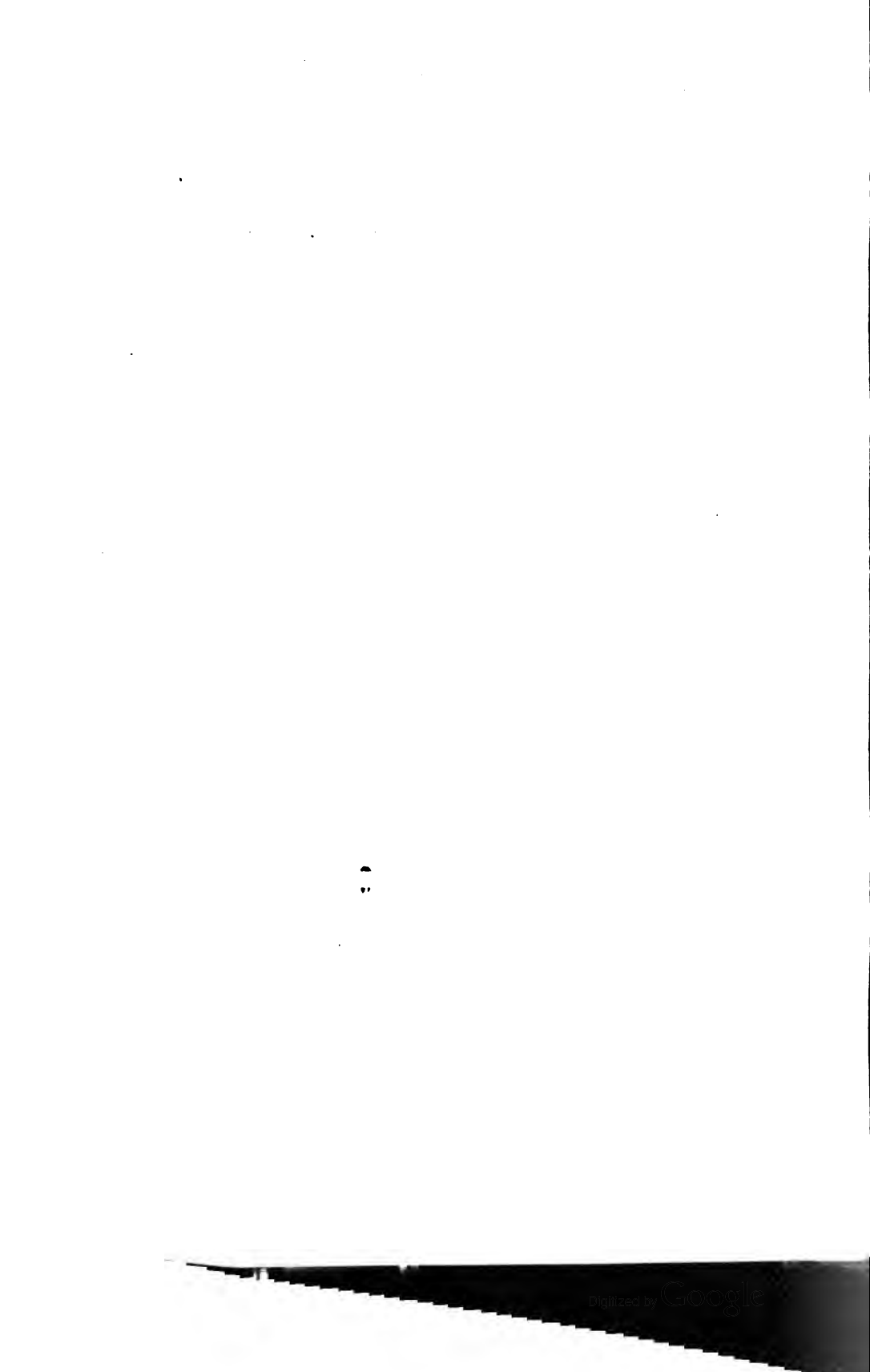
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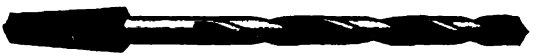

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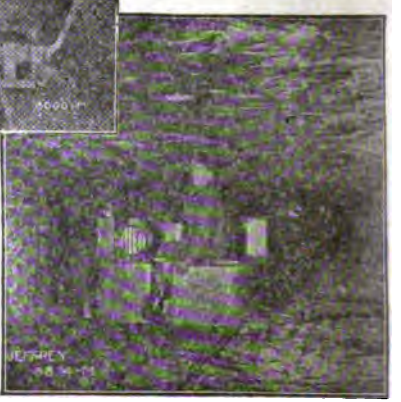

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